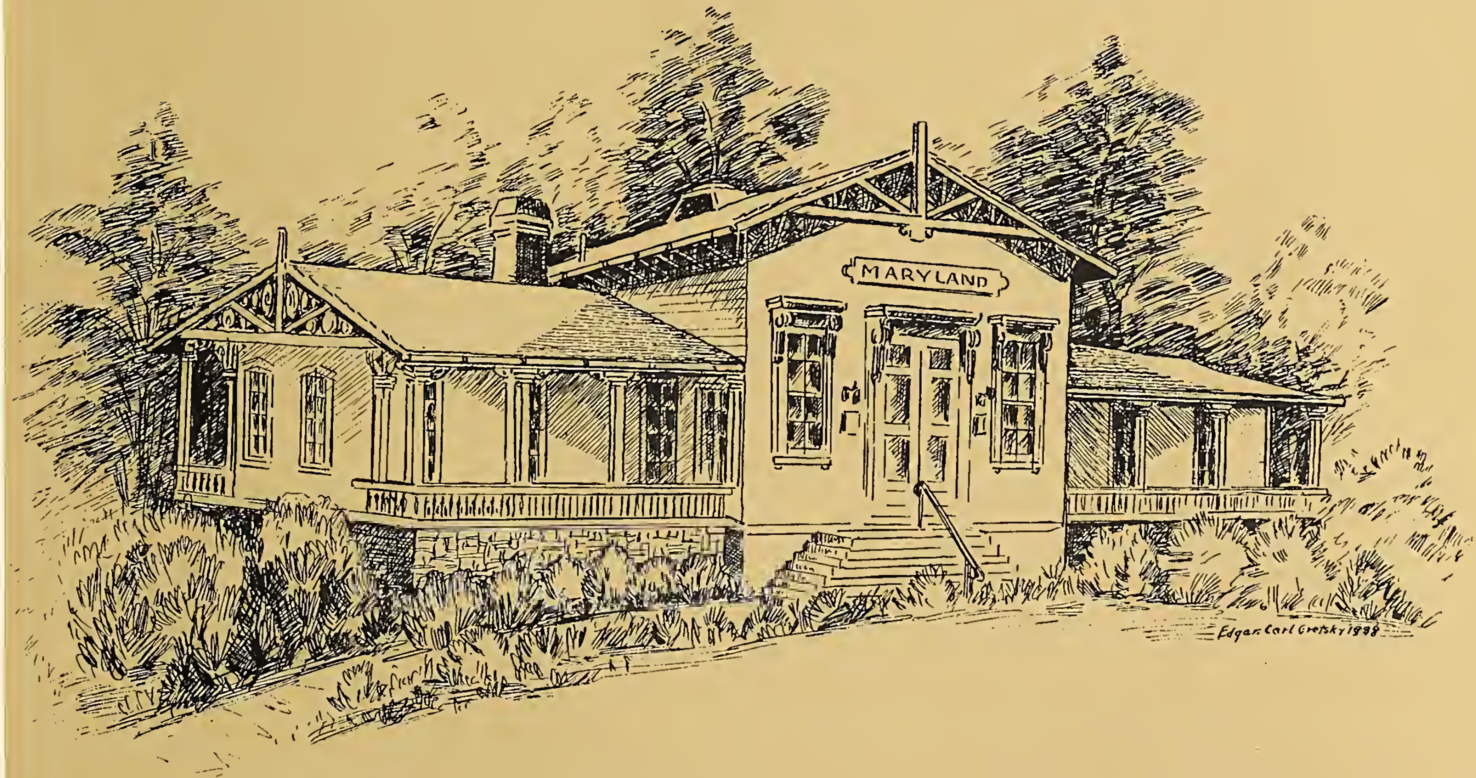
The Maryland Naturalist

THE NATURAL HISTORY SOCIETY OF MARYLAND



Volume 37, Number 1-2 Jan./June 1993

ISSN 0096-4158

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Volume 37, Number 1-2 Jan./June 1993

Contents

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Mailing Date: 15 November 1993

Cover Illustration: The Maryland House was built in 1876 for the Centennial Exposition in Philadelphia. Afterwards, it was dismantled and brought back to Maryland to be re-erected at its present location in Druid Hill Park. In 1936 the building was granted to the Natural History Society of Maryland for use as a natural history museum. The museum was maintained by the Society until 1975, when the City of Baltimore reclaimed it for other uses. The cover illustration is an original pen and ink drawing made by Edger Gretsky in 1938.

Reflections on Roger Conant's Contributions to Regional Herpetology

My mother had just driven me from Towson to Bear Hills in Baltimore County, dropping me off with instructions to be ready when she returned to pick me up in exactly three hours. If she had even a hint as to what I was about to do she would never have let me out of the car. With little difficulty I found the entrance to the abandoned chromium mine, turned on my flashlight and proceeded in. The floor of the shaft was covered with water that was in places thigh deep. Submerged rocks fallen from the walls and ceiling slowed my progress. Somewhere near the back of the mine, where the water was the deepest and the light from the entrance most faint, I spotted the object of my mini expedition, my first ever long-tailed salamander. Looking back on that very wet and very cold experience, it was not a bad afternoon's work for an eighth grader, but I would never have been able to find that salamander had it not been for Robert Simmons, who provided me with directions to the precise locality.

In fact, for me, and many others, Maryland herpetology in the 1950's was little more than a gazetteer of localities for this and that. There were well known places to catch fence lizards and other sites for racerunners. While many of us knew where to find most local species, no one, not even the older and more experienced members of the Natural History Society of Maryland, really knew much about the overall distributions of species in the state. The situation was made worse by the fact that no one seemed to have a very good idea of the distribution of most of these creatures in adjacent states. Publications that delineated the limits of species distributions were widely scattered, difficult to obtain, and often inaccurate. Today's herpetologists may find it difficult to understand the nature of our "field work" in the 1950's, and could criticize its lack of focus, but that's how things were, and they did not get appreciably better until the first edition of Roger Conant's field guide was published in 1958.

The range maps that Conant provided for each species in the first field guide were an important original contribution. The ranges of some species had previously been mapped in monographs or other scientific publications, but no one had ever attempted to provide accurate distribution maps for all of the species and subspecies of amphibians and reptiles occurring in eastern North America. The accuracy and usefulness of Conant's maps can not be overstated. They showed the distributional limits of each species and subspecies in detail. At the time most field guides on other subjects either did not contain maps or were so poorly researched that the maps they did offer were misleading.

Nearly every reference to distributional information on Maryland's herpetofauna was compiled after the appearance of the first edition of Conant's field guide. The single exception was Robert McCauley's *The Reptiles of Maryland and the District of Columbia* (which Conant reviewed for Copeia in 1946). John Cooper's distributional survey of Maryland, the first compilation of records by region and county, appeared in 1960. Revised surveys (1968 and 1975) by Herb Harris were expanded from Cooper's original format, and included distributional maps. In the 1960's and 1970's the distribution of most Maryland species became fairly well documented by a sizable group of young amateur herpetologists. They were inspired by these field guides and surveys to do something beyond keeping pet snakes. We are all impressed with how complex the distribution of animals in a state as small as Maryland can be, and now that the distributions are well known, one becomes hard pressed to think of more that a few species that are found throughout the state.

Conant knew that his maps would require revision almost as soon as they appeared in print. Ironically, the information for the revisions came mostly from persons armed with knowledge gained from the field guide itself. In their quest to verify and expand the ranges delineated in Conant's maps, students of herpetology turned over most of the logs and stones in eastern North America. The subsequent range adjustments were interesting, but in most cases zoogeographically minor. A comparison of the distribution maps in the 1958 edition with those in the latest 1991 edition clearly demonstrates that Conant had the basic ranges worked out over 30 years ago.

Another major innovation was the use of Isabelle Hunt Conant's hand-colored photographs of reptiles and amphibians, which supplemented the text descriptions and were used to point out specific diagnostic characters that could be used in the field. Up to that time, diagnostic features were often subtle differences buried in scientific publications; characters that were, more often than not, based on faded museum specimens.

Figure 1. Roger and Isabelle Hunt Conant on the tailgate of their Oldsmobile station wagon, October 7, 1949. The rack of boxes was designed to hold snake bags for transporting live reptiles back to the Philadelphia Zoo. Photograph provided by Roger Conant.

Now, of course, there are whole generations of naturalists, and amateur and professional herpetologists who have grown up in a world full of field guides that explain everything from mushrooms to astronomy. These books are basic sources of information that are taken for granted, and are generally the initial reference consulted by those starting work on a species or in a specific geographic area. Field guides conveniently condense information that most persons would have difficulty acquiring in a life-time of field work and library research.

When Roger and Isabelle Conant were working on the second (1975) edition of the field guide I corresponded with them about some minor range refinements and supplied them with a few specimens for illustration in their revised plates. Several times I was invited to Hyla Holler, their home in rural New Jersey, to review the distribution maps. They were charming hosts, and once Isabelle even served snapper soup. I was impressed with the Conants' library, their well-organized reprint collection and the volumes of correspondence that provided much of the documentation for the maps and text of the field guide.

Those not having a deep interest in herpetology may not be aware that the three editions of Conant's field guide do not represent his only major contributions to the field. Recently he and his long-time friend and colleague, the late Howard K. Gloyd, completed a major monograph entitled *Snakes of the Agkistrodon Complex.* The 614 page book represents nearly 60 years of collaboration, a period during which these authors named one-third of the 33 species and subspecies of the snakes belonging to that group. Reading the preface to this monograph one senses Conant's dedication to herpetology and his abiding loyalty to his dear friend. The book is already considered a classic, and is every bit as important a contribution as Gloyd's *The Rattlesnakes, Genera Sistrurus and Crotalus. A Study in Zoogeography and Evolution.* Another major contribution was Conant's series of systematic papers on the water snakes, particularly his scholarly study of the Mexican fauna. That phase of his research led to the recognition and description of eight subspecies of North American and Mexican watersnakes (*Nerodia*). Conant's *The Reptiles of Ohio* is also considered to be something of a classic, and was used by Robert McCauley as a model for *The Reptiles of Maryland and the District of Columbia.*

Many of Conant's other works were also milestones in herpetology and strongly influenced the growth of this science. For instance, he served as the ASIH committee chairman on common names and in the introduction of "Common Names for North American Amphibians and Reptiles" he showed both a sense of humor and the ability to hammer home a point. When he wished to illustrate the need for standardized common names, he quoted Ward, who had written "In the original version of this table, Nuttall mentions *Cynocephalus mormon* and *sphinx*, omitting their common names. I have learned since that one is the mandrill and the other the guinea baboon. Since Nuttall wrote in 1904, these names have undergone the following vagaries: *Cynocephalus mormon* became *Papio mormon*, otherwise *Papio maimon*, which turned to *Papio sphinx.* This might well have been confused with *Cynocephalus*, now become *Papio sphinx*, had not the latter meanwhile been turned into *Papio papio.* This danger averted, *Papio sphinx* now became *Mandrilus sphinx*, while *Papio papio* became *Papio comatus.* All I can say to this is, thank heavens one is called the mandrill and the other the guinea baboon. Anyone who supposes, as Nuttall apparently did, that he improves matters by giving their taxonomic designations is only asking for trouble, and is more likely to mislead the reader than to inform him." The publication served its purpose well, and authors and editors of herpetological literature have generally adhered to "standardized" common names ever since. For anyone familiar with earlier publications on reptiles and amphibians, this was an accomplishment of considerable magnitude.

In addition to the previously cited publications, Roger Conant has authored or coauthored nearly 230 other contributions. Among them are numerous significant papers dealing with the husbandry of amphibians and reptiles, their biology, systematics and zoogeography. Conant's primary interest clearly was, and still is, the study of the zoogeography of reptiles and amphibians. If one reviews his work as a collective unit, it is apparent that he did two things. First, he identified systematic and zoogeographic problems that were in need of investigation. And, second, he worked to resolve several of the most difficult of these (i.e., *Agkistrodon*, watersnakes, Atlantic Coastal Plain milk snakes) and published his research and results in a long series of superb papers. We should keep in mind that Conant accomplished this while holding down full-time, very demanding, positions (ranging from curator to director) in major zoos. For instance, while completing the second edition of the field guide he was director of the Philadelphia Zoo, consequently, his field work was conducted on weekends and during vacations, and his writing was done mostly at night.

In the following article in this journal, Roger Conant writes about his years of field work on the Delmarva Peninsula. That discussion will eventually be included in his autobiography. Several other "chapters," reviewing other periods of his life were previously published in the Bulletin of the Chicago Herpetological Society. It is hoped that others will follow, and that his completed memoirs will soon be made available to students of herpetology and natural history.

No research into any aspect of herpetology involving the Delmarva Peninsula could be done without reference to Conant's publications. A list of those most pertinent to the Delmarva Peninsula has been appended to this commentary. Much of Conant's Delmarva Peninsula research was geared toward the ultimate publication of a major paper on its herpetology. While other responsibilities have led Dr. Conant in other academic directions, I hope that those intrusted with the information he compiled will eventually complete the anticipated masterwork.

Roger Conant's recollections of field work on the Delmarva are entertaining. But his low key, anecdotal approach should not lead to the conclusion that they were unimportant. Because of the extensive modification that the Delmarva has experienced since Conant started to work there in 1935, much of the information that he acquired would now be difficult or impossible to obtain. None the less, there are still many unspoiled places on the Delmarva, but they are scattered and isolated. The main highways pass by extensive croplands and vast chicken farms (perhaps explaining why the Blue Hen is the state bird of Delaware) and intersect in sprawling towns. A casual visitor would be unimpressed. Yet the side roads and back roads, and best of all the dirt roads, still lead to some interesting places, places where bits of information are still hidden, and the promise of intriguing zoogeographical finds seduces even middle-aged naturalists to leave their cushioned chairs and climate-controlled offices.

Publications Pertinent to the Herpetology of the Delmarva Peninsula
Authored or Coauthored by Roger Conant

1940. *Rana virgatipes* in Delaware. Herpetologica, Vol. 1, No. 7, pp. 176-177.

1940. Miscellaneous Notes on the Eggs and Young of Reptiles. Zoologica, Vol. XXV, Pt. 1, pp. 33-48. (with Alexander Downs, Jr.)

1943. The Milk Snakes of the Atlantic Coastal Plain. Proc. New England Zool. Club, Vol. XXII, pp. 3-24, pls. II-IV, 1 map.

1943. *Natrix erythrogaster erythrogaster* in the Northeastern Part of its Range. Herpetologica, Vol. 2, No. 5, pp. 83-86.

1945. An Annotated Check List of the Amphibians and Reptiles of the Del-Mar-Va Peninsula. Soc. Nat. Hist. Delaware, pp. 1-8, 1 map.

1946. Intergradation Among Ring-necked Snakes from Southern New Jersey and the Del-Mar-Va Peninsula. Bull. Chicago Acad. Sci., Vol 7, No. 10, pp. 473-482, 1 map.

1946. REVIEW OF: "The Reptiles of Maryland and the District of Columbia," by Robert H. McCauley, Jr. Copeia, 1946, No. 2, p. 110.

1947. Reptiles and Amphibians of the Northeastern States. Zool. Soc. Philadelphia, pp. 1-40, 122 figs., 1 map. (Second edition, 1952; and third edition, 1957.)

1947. The Carpenter Frog in Maryland. Maryland a Journal of Natural History, Vol. XVII, No. 4, pp. 72-73.

1947. Reptiles and Amphibians in Delaware. Delaware, a History of the First State, pp. 23-25.

1949. Two New Races of *Natrix erythrogaster*. Copeia, 1949, No. 1, pp. 1-15, pl. I.

1955. Notes on *Natrix erythrogaster* from the Eastern and Western Extremes of its range. Nat. Hist. Misc., No. 147, pp. 1-3.

1955. LETTER: Terrapin as Food. British Jour. Herp., Vol. 1, No. 12, pp. 252-253.

1957. The Eastern Mud Salamander, *Pseudotriton montanus montanus*: A New State Record for New Jersey. Copeia, 1957, No. 2, pp. 152-153.

1958. Notes on the Herpetology of the Delmarva Peninsula. Copeia, 1958, No. 1, pp 50-52.

1958. A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Houghton Mifflin Company, Boston, Mass., pp. i-xviii, 1-429, figs. 1-105, pls. 1-48, maps 1-311, 1 map, 33 illus.

1975. A Field Guide to Reptiles and Amphibians of Eastern and Central North America (second edition). Houghton Mifflin Company, Boston, Mass., pp. 1-xviii, 1-429, figs., 1-105, pls. 1-48, maps 1-311, i map, 33 illus.

1976. Reptiles and Amphibians of the Virginia Barrier Islands, Including Several Islands not Examined in the Present Study. *In* Dueser, Raymond E., et al., The Vertebrate Zoogeography of the Virginia Coast Reserve, Table 31:5080509. From a report in the Virginia Coast Reserve Study, Gerard J. Hennessey, Study Director, Volume 1, The Ecosystem Description.

1981. Herpetofauna (Reptiles and Amphibians) of the Virginia Coast Reserve. *In* MacLeod, Bruce, and Gerard J. Hennessey (eds.). The Islands, Official Newsletter of the Virginia Coast Reserve, the Nature Conservancy, pp. 6-7.

1990. Snakes of the *Agkistrodon* Complex: A Monographic Review. Society for the Study of Amphibians and Reptiles, Contributions to Herpetology, No. 6, pp. i-vi, 1-614, figs. 1-60, pls. 1-32 (in color) and 33-52 (black-and-white), maps 1-28. Nine ancillary papers by various authors. (Howard K. Gloyd senior author.)

1990. Herpetofauna of the Virginia Barrier Islands: Distribution and Biogeography. Abstract from the Program of Annual Joint Meeting of the Herpetologists League and the Society for the Study of Amphibians and Reptiles, New Orleans, Louisiana, August 5-9. (With Joseph C. Mitchell and Christopher A. Pague.)

1991. A Field Guide to Reptiles and Amphibians of Eastern and Central North America (third edition). Houghton Mifflin Company, Boston, Mass. pp. i-vviii, 1-450, figs. 1-120, pls. 1-48 (all in color), maps 1-333, 1 map, 33 ills. (With Joseph T. Collins.)

Dave Lee

The Delmarva Peninsula

Roger Conant

How different the Delmarva Peninsula was a half century ago. Except for scattered towns and a few small cities it was almost entirely rural and lightly populated by humankind. Also, the term Delmarva had not yet come into general use. Some of my more scholarly friends in the Wilmington area corrected me every time I mentioned it. They preferred to call the several states by name -- Delaware, Maryland, and Virginia -- or to use the "Eastern Shore."

Delmarva was isolated in a very real sense. There was no way to get across Chesapeake Bay except by boat. North and south trending roads gave access to the markets and activities in Wilmington and beyond, but toward the south there was no exit except to take the ferry from Cape Charles to the Norfolk region. For anyone who was not in a hurry, such a trip was an enjoyable boon. One could drive his car or truck aboard, have a leisurely meal in the ship's dining salon, if desired, and then relax to enjoy the scenery. There were always other boats in sight, as well as sea birds of several kinds.

The Peninsula, in general, was a quiet, bucolic oasis along the bustling Atlantic Seaboard, and life moved at a slow pace. The residents engaged chiefly in agriculture. There had been some lumbering as was attested by the occasional abandoned sawdust piles we found while exploring the area, and which had been left in the wake of the itinerant sawmills of earlier years. The Great Cedar Swamp, along the southern border of Delaware, had long since been logged. What a vast wilderness it must have been in colonial days. It consisted of Atlantic white-cedar (*Chamaecyparis*) and bald cypress (*Taxodium*), and it occupied an estimated 50,000 acres. It was destroyed by a catastrophic fire in 1782 that raced through it after a succession of dry seasons, but much of the area was still swampy.

Those families who lived near the coasts, east or west, derived their livelihood from the water, the home of myriads of oysters, clams, crabs, fishes of various kinds, and even terrapins, although those turtles were far less in demand than they had been previously.

In time the Chesapeake Bay Bridge was built, giving access from 1952 onward to the Atlantic seacoast for hoards of people seeking to escape the sticky summer heat of the Baltimore-Washington megalopolis complex. Later, the over-and-under water engineering marvel was completed, the Chesapeake Bay Bridge-Tunnel. It opened in 1964, and immediately became a shortcut for avoiding the heavy traffic on the western shore. The great influx of people improved the economy of the region, but it destroyed the peace and quiet, and a lot of the wildlife suffered.

As a person who spent most of his life working in zoological gardens, who loved animals, and who was an avid herpetologist, the change was anything but welcome. Happily, most of my field work on the Peninsula was done well before the advent of World War II, although it continued for a few years after gasoline rationing came to an end. How fortunate I was to be there frequently and before the great transformation took place.

In 1935 I returned to Philadelphia and began to serve as Curator of Reptiles at the zoo after a six-year stint in the same capacity and, later, as General Curator of the Toledo (Ohio) Zoo.

While I was in the Buckeye State, I did field work in 87 of its 88 counties that eventually led to my "Reptiles of Ohio," which was first published in 1938. Once back east again, I made an occasional foray into the New Jersey Pine Barrens, but I missed the opportunity of getting into the field for a definite purpose. Carl F. Kauffeld, of the Staten Island (New York) Zoo, was then investigating the herpetofauna of the Pine Barrens, but I soon discovered that little work had been done on the Delmarva Peninsula. Witmer Stone, Henry W. Fowler, and Emmett Reid Dunn, all associated with the Academy of Natural Sciences in Philadelphia, had published short papers on specimens collected on the Peninsula, but no study in depth had ever been attempted. Here was a challenge for me. I thoroughly enjoyed being in the field far away from the noise, fumes, bustle, and crowds of people that characterize cities, but I wanted to do something worthwhile, herpetologically speaking. Documenting the occurrence of various species, making distribution maps, and preserving voucher specimens would all add to our knowledge of the amphibians and reptiles of the area. I began to make plans for a general survey of Delmarva, and an early decision was to place the northern edge of my study area along the Pennsylvania state line, thus including all of Delaware and the eastern segment of Maryland to the Susquehanna River and Chesapeake Bay. The two Virginia counties were, of course, far to the south. A better and physiographic boundary might have been the Fall Line, but that passed right through the city of Wilmington, just as it does through many other eastern cities and towns. The Fall Line (actually a narrow zone), which is little known to most people nowadays, aside from historians and geologists, marks the outer boundary of the Piedmont Plateau where the streams flowing to the sea accelerate as they leave the hard rocks and cut into the softer strata of the Coastal Plain. The rapid movement of water in colonial days provided power for grist and other mills, and early settlers tended to cluster near where their grain could be ground. Towns and eventually cities developed on the sites, especially if there were port facilities nearby. Trenton, Philadelphia, Wilmington, Baltimore, Washington, Richmond, and many other smaller cities are all on or close to the Fall Line.

A brief look at a road map indicated that the shortest route to the Peninsula from suburban Philadelphia was through Chester, Marcus Hook, and Wilmington. I tried it only once. The traffic was horrendous even in the 1930's. There were no by-passes, and moving through those cities was at a crawl, with stops at virtually every corner. After a few exploratory attempts, I discovered a way around Wilmington to the west, using rural roads, and thereby cutting the time of passage by at least an hour. Time was precious, because all I could manage at first were one-day trips. Members of the Junior Zoological Society, friends, and zoo staff members, and often my young son, Skip, accompanied me, so we went on Saturdays when there was no school. All Philadelphia Zoo personnel, except the Director, worked a six-day week, but I was permitted to swap my usual Friday off for Saturday so I could be in the field. We would start, whenever possible, on Friday evenings after out respective dinners, drive a hundred miles or more and stop frequently, especially in the spring, to hear and to sample the huge frog choruses. We would then camp out or sleep in my ancient Chevrolet, and work northward the following day to get home Saturday night. The longer distances far down the Peninsula were too much for one-day trips, and they had to be reserved for vacation periods or when I had an extra day coming to me for having worked on my usual day off. Cape Charles, near the southern tip of the Peninsula, was well over 200 miles from the Philadelphia area. At least a two-day trip was necessary to reach the Virginia counties, work in them, and then get back at a reasonable time on Sundays.

Just as I had done when I first began the survey of the reptiles of Ohio, I sought to learn everything I could about the area where I planned to work, the Delmarva Peninsula. The botanists had long been active and two of them, the highly conservative Frank Morton Jones and Robert R. Tatnall, were leading spirits in the Society of Natural History of Delaware. I looked them up in Wilmington. They were polite, but I had a sneaking suspicion that they considered me as little more that a youthful upstart, until I showed them a copy of my "Reptiles of Ohio." That broke the ice, so to speak, and I was invited to give a lecture on reptiles and amphibians at a regular public meeting of the Society. Several years later, in 1945, the Delaware Society printed my "An Annotated Check List of the Amphibians and Reptiles of the Del-Mar-Va Peninsula," which is now thoroughly outdated. They forced me to use hyphens for Delmarva, a term they were not yet willing to accept. Nor would they permit me to credit the map on the inside front cover (reproduced here, Figure 1) to my close friend and colleague, Edmond V. Malnate, who drafted it with great care. They even balked at putting his initials under the map itself. We let Dr. Tatnall use the same base map in his lengthy and scholarly "Flora of Delaware and the Eastern Shore," which was published in 1946, but no credit was given to either of us. It was against their editorial policy, I assume, to let readers know who executed illustrations. By the time I gave my last lecture at the same Society, about our African trip in 1968, the arch-conservatism had disappeared.

It was obvious from the very start that there were only two physiographic provinces involved. Most of Delmarva was part of the Atlantic Coastal Plain, but the northernmost portions of Cecil County, Maryland, and New Castle County, Delaware, were in the Piedmont. The narrow Fall Line zone separated the two. Such species as the long-tailed salamander, the slimy salamander, and the northern copperhead were restricted to suitable habitats in the Piedmont and along the adjacent Fall Line zone. Other species occurred only in the Coastal Plain. Still others were widespread and they turned up more of less throughout the entire region. An interesting discovery was that the Elk Neck promontory that extends roughly southwest between the Elk and Northeast rivers, and which is rocky in part, supported at least small populations that otherwise were restricted to the Piedmont. Elk Neck also had strong populations of Coastal Plain species. As along the Fall Line zone, Elk Neck was the home of a mixture.

A surprise that came into focus after I began plotting localities on distribution maps was another "boundary line" that appeared on no map I could ever find. In Sussex County, Delaware, and the adjacent Maryland counties to the west, the soil was sandy, a mixture of sand and other components, and it differed from the soils farther north. A number of species occurred in suitable habitats from Sussex County southward that appeared to be totally absent from areas farther north. Included among them were the carpenter frog, the corn snake, and the red-bellied water snake.

I never did find a satisfactory explanation about why there was a "barrier" across the center of the Peninsula. I discussed it with my friends in Wilmington, and Dr. Tatnall suggested that it more or less coincided with the northern limit of pure stands of the loblolly pine, *Pinus taeda*, as he had observed them during his many years of botanizing up and down the Peninsula. The loblollies appeared to do well in the sandy soil, so the "boundary" may have been of edaphic (soil-related) origin. Nonetheless, I showed the "boundary" on my map of the region.

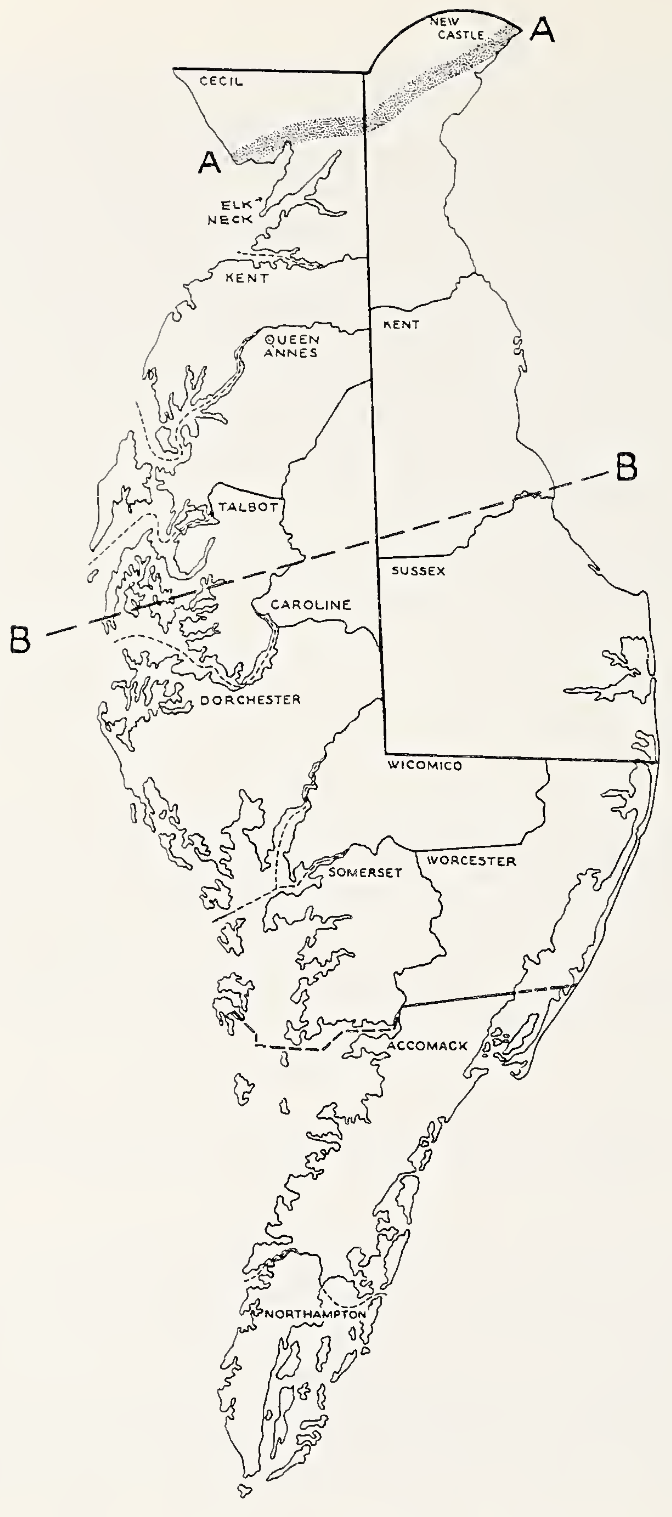


Figure 1. The Delmarva Peninsula, consisting of Delaware and the Eastern Shore counties of Maryland and Virginia, may be divided into two physiographic portions: (1) The Piedmont Province, characterized by hills and valleys (only the northern parts of Cecil and New Castle counties); and (2) The Atlantic Coastal Plain which is relatively flat. The Fall Line (A-A), which is actually a narrow "zone," separates the two Provinces. The line B-B (based upon information supplied by Dr. R. R. Tatnall, of Wilmington) marks the approximate northern limits of pure stands of *Pinus taeda*, the loblolly pine. The southern half of the Peninsula is characterized by pine woods and sandy soil. Elk Neck, which exhibits a slightly rugged terrain, is the home of an interesting mixture of both Piedmont and Coastal Plain plants and animals. Map prepared by Edmond V. Malnate.

Another discovery was that the American toad, *Bufo americanus*, which was abundant in the Piedmont and also occurred on Elk Neck, was missing from the northern part of the Coastal Plain. Yet it reappeared south of the "barrier." It was the same with the copperhead. That venomous snake was in the Piedmont and along the Fall Line and, like the toad, it skipped the upper part of the Peninsula, but was present from Sussex County to and through the Virginia Counties. The only difference was that, whereas the copperheads in the north were identifiable as *Agkistrodon contortrix mokasen*, those in the south belonged to the widely distributed intergrading population designated as *Agkistrodon contortrix contortrix* x *mokasen*. But I was not to learn that until many decades later when I became deeply immersed in the study of the genus *Agkistrodon* (by Howard K. Gloyd and Conant, and published in 1990).

Our first forays to Delmarva were short one-day trips west and north of Wilmington and to the vicinity of the Conowingo Dam, a huge hydroelectric impoundment not far from the mouth of the Susquehanna River. Just south of the dam, paralleling the river, and easily accessible by road, we found a series of swampy areas that, over the years, through our own work and that of others, yielded many interesting species. Included were all three of the eastern turtles of the genus *Clemmys*. Of these, the wood turtle, *Clemmys insculpta*, was confined to the Piedmont and Elk Neck, and the bog turtle, *Clemmys muhlenbergii*, was similarly distributed, although it turned up much later well down in New Castle County. The spotted turtle (*Clemmys guttata*) occurred all over the Peninsula, and we found it to be relatively abundant in virtually all suitable habitats. The map turtle, *Graptemys geographica*, was more or less restricted to the Susquehanna, but it also occurred along the Northeast River on Elk Neck.

I have so much interesting information about the "herps" of Delmarva that I could write dozens of pages, but space will not permit. So I must generalize and restrict myself to some of the more important observations and events.

One of my overall memories of our field work in the region is that so many species were abundant. On rainy spring nights many of the frog choruses were so enormous and deafening that one species could not be distinguished from another by ear. Sometimes there were so many frogs and/or toads migrating across the paved roads to the nearby breeding ponds and swales that we had to stop the car and shoo them out of the way. There were a few DOR's ("herp" slang for specimens found dead on the road where cars had run over them), but the traffic was so light that the attrition on the populations was negligible.

Snakes were abundant, and it was not unusual to see live ones, even large individuals, crossing the road in spring or autumn, even in broad daylight. One day, near Machipongo in the more southern of the two Virginia counties, Phil Edwards, a member of the zoo staff, was relieving me at the steering wheel of my car. He had never been on a field trip previously and, as we found out, he went along just out of curiosity. He was driving slowly along when a large black rat snake started across the road. Both Ed Malnate, who was with us, and I saw it and yelled, "stop!" Phil didn't see it, paid no attention to our loud voices, and, of course, ran over and killed it. I had to pickle it with formaldehyde, using a hypodermic needle and syringe, as I did with every other DOR reptile or amphibian that was not too badly damaged and was salvageable for a study specimen. I hope I can be forgiven for thinking, for an instant, about how suitable it would be to jab Phil with the needle. If he had not run over the snake it would have gone back with us for the Philadelphia Zoo's reptile house.

On that same trip, at about 10:00 PM, as we were looking for frogs by flashlight, we discovered another large black rat snake climbing up a tall stump amidst masses of poison ivy. That one we didn't try to catch.

Because I wanted voucher specimens of frogs from different localities, and the easiest way to preserve them was at my home base later, I needed some way to distinguish where they were caught. As we moved from pond to pond, we would put a few specimens, often of different species, into a thoroughly wet collecting bag, add a handful of sodden moss or vegetable debris, and then toss in a paper note with the locality written on it. That led to problems, because the paper might be almost illegible the next morning. So I acquired a series of bronze identification tags, each an inch in diameter, stamped with the letters of the alphabet, and each punched with a small hole that permitted them to be strung on a small dispenser. Such tags were impervious to frog excrement and assorted debris. We dropped G, for example, into a bag with the frogs and wrote the data opposite "G" in a notebook.

My first deep penetration down the Peninsula, on May 2 and 3, 1936, was a memorable one. I had recently become the volunteer godfather of the Junior Zoological Society of Philadelphia, and two of the most active members participated. One was William F. "Bucky" Reeves who was eventually to earn my admiration for pulling himself up from poverty to become a professional lecturer on natural history. Every Saturday he and one or two of his friends hitchhiked from distant Riverside, New Jersey, to attend the Junior Society's meetings. The other was James "Jimmy" Emlen, then perhaps twelve years of age, and a member of a prominent Quaker family. Jimmy's father George Emlen, offered to drive us down and back and to "camp out" overnight. He said we should fill his car, so Mark Mooney, Jr., was invited to go along. He was then the zoo's unsalaried photographer, and through his enterprise I have a series of pictorial mementos of the trip. One includes a picture of me on my knees in the dirt pickling a DOR kingsnake we had salvaged (Plate 2).

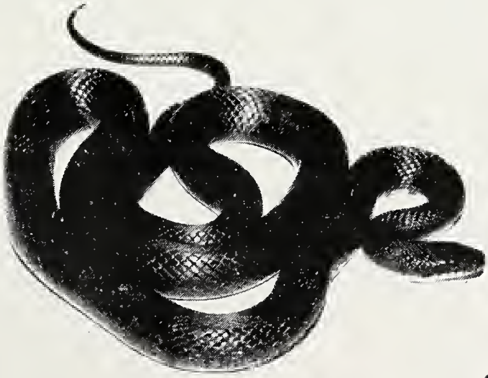
By a stroke of good luck we explored and collected near Millsboro, Delaware, a highly productive area to which I was to return again and again, frequently as a promising stop on longer trips. South of that town was a vast swampy region that surely was part of the site of the Great Cedar Swamp that had suffered the catastrophic conflagration of the late eighteenth century, and subsequent and repeated burns as growth was renewed. Nearby were deep woods, swamps, abandoned sawdust piles, and rustic trails leading back into prime "herp" habitat. We caught several snakes on our 1936 trip, including three black racers, one of which I ran down personally with my hip boots flapping as I went. We had a splendid time, and I developed a warm friendship with the Emlens.

Plate 1 (Opposite). Amphibians and Reptiles Indigenous to the Delmarva Peninsula: A, carpenter frog, *Rana virgatipes;* B, American toad, *Bufo americanus*; C, five-lined skink, *Eumeces fasciatus*; D, marbled salamander, *Ambystoma opacum*; E, eastern hognose snake, *Heterodon platirhinos*; F, eastern kingsnake, *Lampropeltis getula*; G, black rat snake, *Elaphe obsoleta*; H, eastern painted turtle, *Chrysemys picta*. Photos by Isabelle Hunt Conant from the photographic collection of Roger and Isabelle H. Conant.


A B


C D


E F




G H

The Millsboro area yielded two amphibians of special interest. While we were on that first excursion, Bucky Reeves and I waded into a prairie-like swamp about five miles south of town. The swamp was roughly square and about a fourth of a mile across. It contained an abundance of sphagnum and clumps of cattails, and rotting logs were scattered on the surface. A brief shower stimulated a chorus of carpenter frogs, *Rana virgatipes*, and we collected a few, the first ever recorded from the Delmarva Peninsula.

Almost exactly six years later, Nigel O'Conner Wolff, of the zoo staff, and I spent an hour in the same swamp. We separated, and I turned over innumerable small flat mats of sphagnum lying on the decaying logs or clumps of fairly firm mud around the perimeter of the swamp. I finally caught up with Nigel, and he asked, "What are you looking for?" I explained that four-toed salamanders, *Hemidactylium scutatum*, sometimes could be found under flat mats of sphagnum. With that he reached down right where he stood and scooped up a handful of moss and turned it over. "Is this it?" he asked. Sure enough, he had one. Ironically, it was the only four-toed salamander we ever found in the area, despite repeated visits.

During my youth, I had spent four summers serving as a counselor at a Boy Scout camp along the Metedeconk River in the New Jersey Pine Barrens. The shoreline, along which thick masses of floating vegetation accumulated in every cove or small indentation along the broad river, was the hiding place of seemingly countless water snakes, many of them in excess of three feet in length. By stalking and then patiently waiting for a head to protrude, I became adept at catching them, but almost every time I was bitten, sometimes severely. Later I began experimenting with a new technique, which consisted of slinging any large snake between my legs once I grabbed it at any part of its body. My heavy dungarees protected me from attacks from the rear. I would slowly draw the snake forward, tail first, through my hand until I felt the taper to the snake's head. I then grasped it by the neck, and I eventually became so proficient that I caught large snakes of several species with nary a bite.

I guess I was a born teacher, because I was always showing my young companions all sorts of things about reptiles and amphibians, where to look for them, how to handle them, and so on. One warm evening in southern Delaware we overturned a wide piece of board and beneath it there was a large kingsnake. I waved back the three teenagers and my young son, Skip, and told them I would demonstrate how to catch it without being bitten. I grabbed the snake, tossed it between my legs, and began the well-practiced routine. The snake did not cooperate, however. Instead, it thrust its head through my legs, next to its body, seized my

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Plate 2 (Opposite). A, Sign for the Wye Oak. B, The Wye Oak with Conant standing to the right of trunk (April 10, 1947). C, Pocomoke River, east of Willards, Wicomico County, Maryland (May 3, 1936). D, Pocomoke River at same locality after channelization (Spring, 1945). The riparian swamp and much of its wildlife had vanished. E, Ruins of Coast Guard Station, Hog Island, Northampton County, Virginia (October 19, 1948). Osprey nest in a dead tree. F, Close-up of ruins. The Coast Guard Station was originally built about a mile from the ocean. G, Roger Conant preserving a DOR kingsnake under field conditions, south of Millsboro, Sussex County, Delaware (May 2, 1936). H, A long-abandoned sawdust pile strewn with bark slabs near Corbin, Worcester County, Maryland. A favorite hiding place for secretive reptiles and occasional amphibians (April 12, 1947). Photos C and G by Mark Mooney, Jr.; all others by Isabelle Hunt Conant. From the photographic collection of Roger and Isabelle H. Conant.


THE WYE OAK
THE LARGEST WHITE OAK IN
THE UNITED STATES. ESTIMATED
TO BE 400 YEARS OLD (1940).
DEEDED TO THE STATE OF
MARYLAND SEPT. 20, 1939, AND
MADE A STATE PARK.
STATE ROADS COMMISSION OF MARYLAND
A
B
C
D
E
F
H

thumb in its mouth and started chewing, bringing blood repeatedly. The lad who laughed the loudest and longest was my son. And to think I had caught many a kingsnake by just picking it up and having it behave at once like a thoroughly tame snake that was used to being handled!

Edward Deal, Jr., was one of a succession of printers at the Philadelphia Zoo. His job was to set the type for the copy I gave him, print it on waterproof cardboard, dunk it into preservative, and finally to erect the finished sign in place in front of the animal concerned. Eddie was a city boy who had never been in the country. He heard so much about our field work from the Junior Society members, that he asked me, timidly, if he could go along on a trip. Talking to me about such a great favor was an ordeal for Eddie. He stuttered, and his affliction was magnified whenever he was under stress or excited. Things worked out so that he and I went down together for two days. From his reactions and enthusiasm it was quickly obvious he was having the great adventure of his life. He was then in his early twenties. He was overwhelmed by the frog choruses, especially since he had never heard a frog make a noise. He revelled in the sights and sounds and smells of rural Delmarva. He marveled as he saw me pick up a live snake from the road, but the climax did not come until the second day.

We were near Locustville on May 20, 1940, in the upper of the two Virginia counties. We had separated for some reason, but I was well within earshot. Suddenly I heard a gurgling sound punctuated with brief yells. Eddie was calling to me as best as he could, but his stuttering had increased so unbelievably that I could not make out a word. I hurried to him, found him in a cold sweat, almost bug-eyed, and pointing to a large hognose snake, *Heterodon platirhinos*, perhaps ten feet from him, that was hissing and going through its amazing act. I moved in close and motioned for him to do likewise so he could watch. Presently the snake opened its mouth, began to writhe, and then turned belly up. After it was completely inert and, to all appearances dead, I turned it over with a stick and explained what was going on. I was able to show Eddie that the snake deliberately turned on its back time after time. I could not really blame him for being scared. He knew nothing about *Heterodon*, and the performance can be frightening for almost any layman. I'll admit that even I, after many years of experience, gave a start whenever I heard the first loud hiss of a hognose snake, just as I invariably did whenever a covey of quail suddenly exploded into action virtually at my feet.

It didn't take me long to find the Rodney Boy Scout Camp on Elk Neck. It was named, I was told, for Cecil Rodney who, although he was sick at the time, rode horseback to Philadelphia as fast as he could to deliver the papers that made Delaware the first state to ratify the Constitution. The camp and I immediately became mutually helpful. Scores of pairs of youthful eyes watched for species I particularly wanted from the Neck, and once or twice each camping season I would give an evening lecture on "herps" using live animals from the zoo's collection. Somewhat later I discovered the Horseshoe Scout Reservation on the Mason-Dixon line where Octoraro Creek makes a great horseshoe-shaped bend. Still later I found other camps well down on the Peninsula, but lecturing was confined to the two northern ones. Even they were too far from home to drive back late at night and be ready for work early the next morning. After the first time or two I took blankets along and used a camp cot on which to sleep. The counselors were very helpful as were many other persons all over Delmarva who saved specimens for me or gave me reports about unusual species they observed here and there.

We worked hard on Delmarva, mostly in the spring and autumn when "herps" were most apt to be in the open or under shelters we could overturn. We crisscrossed the Peninsula, searched through or around seemingly innumerable ponds, swamps, and woodlots, and felt we were learning much about the overall distribution and abundance of the reptiles and amphibians of the region. But we wanted to explore some of the offshore islands that extended from the attenuated Assateague off the coast of Maryland and adjacent Virginia, all the way to Smith Island near the tip of the Peninsula. Only Chincoteague Island was accessible by car. We worked on it but looked longingly at the other islands from the mainland shore. Visits to them had to wait. We were suddenly at war, and gasoline rationing precluded forays down the Peninsula.

After serving for two years with the Volunteer Port Security Force of the U.S. Coast Guard, it was only natural that I turned to the regular Coast Guard for help in reaching the islands. I knew they had stations scattered along the coast and boats for overwater transportation. So I wrote to them in Washington, explained my research project, and asked for assistance. After what seemed like endless red tape, I learned that it was up to the petty officer in charge of each post to decide whether he had the time and manpower to devote to such extracurricular activities as mine. Eventually they gave me the name of Chief John T. Mapp at Wachapreague. I had an encouraging response from him, a date was set and, in the spring of 1947, in the company of Frederick A. Ulmer, Jr., Robert G. Hudson, and Robert Reeves, I spent several days on Parramore and Hog Islands. We stayed at the Coast Guard Station on Parramore and wandered all over that rather large island. It was heavily wooded in part, with fresh- and brackish-water swales and ponds here and there. Our turtle traps yielded a surprisingly large number of snappers. Mud turtles were also common, but the only snakes we found, virtually all of them under boards or other debris, were rough green snakes (*Opheodrys aestivus*) and brown snakes (*Storeria dekayi*).

Hog Island, to which coast guardsmen took us by boat for a day, showed the devastating effects of hurricanes and erosion. A town of a hundred or so residents had existed on it for nearly two centuries, but half the seaward side of the island was now under water, and the breakers had reached the lighthouse that originally had been erected half a mile from the beach. The human residents had long since departed. We found more brown snakes, and I uncovered a clutch of green snake eggs that apparently had hatched the previous season.

In October of the following year (1948), again through the courtesy of Chief Mapp, my wife and I visited the same two islands. Things on Parramore looked just about the same to me, but Hog Island had endured an almost total inundation on October 5. When we arrived there just two weeks later, salt water was standing everywhere except on slightly higher ground. We found no "herps" and all we could do was take photographs of the destruction, the remains of the devastated old Coast Guard station, remnants of the town, and dead trees, some topped with osprey nests. Subsequently we made a brief visit overnight to the small active Coast Guard station on Smith Island, at the southern end of the chain of barrier islands. It, too, had been inundated by the recent high water, and all we found were ground skinks (*Scincella*), although we saw several minks as well as skeins of geese, cormorants, and other waterfowl heading south, just as we had from Hog and Parramore.

I did not return to the islands again until 1975. That was during a trip to the East to see my elderly mother and other members of my family. James D. Anderson, with two of his students, Sally Litwin and Keith Hawthorne, drove us down the Peninsula from New Jersey to "herp" meetings at Williamsburg, Virginia. En route, Gerard J. "Rod" Hennessey, then Director of the Virginia Coast Reserve Study, took us to Parramore, Hog, and Revel Islands. On the return trip I left Williamsburg early with James D. Lazell, and Rod boated us to and gave us an exceedingly interesting day on Smith Island where we found examples of a number of different species, including a kingsnake, black racers, and a snapping turtle. Jim Anderson picked me up later to go back to New Jersey. Things were quite different in several ways. For example, the vegetation on Hog Island was lush and thriving, and diamondback terrapins were observed nesting. Recovery there and on Smith Island had been remarkable during the intervening 27 years.

So, I finally had seen something of the islands which, in comparison with the mainland, had an impoverished fauna. Certain species had reached certain islands, in one way or another, and some of them were abundant in point of individuals in the populations. A review of the "Barrier Island Herpetofauna" was published in 1990. Joseph C. Mitchell and Christopher A. Pague wrote most of it, but they insisted that my name be included as an author, inasmuch as I had pioneered, in a sense, so many years previously.

The trip down and back with Jim Anderson and the students was disheartening. The traffic was dreadful, even on roads paralleling the main highways. It was vastly different from what it had been before the Chesapeake Bay Bridge-Tunnel was opened. There were virtually no DOR's of any kind, and I could not help but think how awful the carnage must have been when cars and heavy trucks raced along the highways on the first warm, rainy nights as the frogs made their way to their traditional breeding ponds and swales. I could well remember some of the depressed acres that quickly filled with water and attracted earsplitting choruses. By 1975 they had been drained or filled to make room for more crops. Along much of the Peninsula it seemed as though there were wall-to-wall fields, to say nothing of the vast chicken farms that had hatched, to use a pun, in many places. We hear and read so much nowadays about the sudden decline in amphibian populations. Not all of that can be blamed on air and water pollution. Destruction of habitats is surely a major factor in a great many parts of the world as the human population gets more and more out of hand, and great quantities of food are in demand.

Our work on the Delmarva Peninsula spawned a number of short contributions in herpetology, such as reporting species found in the area for the first recorded time, evidence of intergradation among ringneck snakes and among milk snakes, and lists for various purposes. Unfortunately, the major report on the area has not been finished. After 1948 my duties at the Philadelphia Zoo increased, and in 1951 work began on the meticulous and time-consuming text, illustrations, and maps for our "Field Guide to Reptiles and Amphibians." I had to put the Delmarva survey on hold, so to speak, but I picked up the threads again soon after my retirement and transfer to the Southwest in 1973. During a series of trips to the east to see my mother and others, I also managed to visit many museums, large and small, to examine their holdings of material from the Peninsula, New Jersey, and adjacent areas. Unexpected circumstances soon overtook me, however, and I was unable to press onward as anticipated. Now that I have been an octogenarian for several years, my chances of ever finishing are tiny at best. I still have all

of my records, a great bale of correspondence about the region, and a large number of ring binders filled with pertinent data and detailed notes, as well as a partly completed text. To save all this information from dying with me, my best bet will be to make it available to trusted colleagues who can use it for their own research. How wonderful it would be if I could have another lifetime to finish all the projects that are well underway, partly executed, or in an advanced planning stage. I must say, however, that among them all, my early work between the Chesapeake Bay and the Atlantic Ocean has left me with wonderful memories. What a marvelous place it was for reptiles and amphibians those many years ago!

There was another reason, cogent and highly personal, why I have happy memories of the Delmarva Peninsula. They concern Isabelle dePeyster Hunt whom I had hired as the Philadelphia Zoo photographer and my assistant during 1942.

Because we had both suffered through disastrous marriages, Isabelle and I were drawn together. We consoled and advised each other. We found, over the years of our association at the zoo, that we worked well together. We made a good team. We were depending on each other in many ways. Were we falling in love? Perhaps it was inevitable, but even before all the legal hurdles had been cleared with our respective erstwhile spouses, we decided we were meant for each other. Where should we be married when the time came?

I had taken Isabelle along with us once or twice on Delmarva trips so she could obtain pictures for use in our zoo magazine "Fauna." I loved the quiet and old-fashioned atmosphere of the Peninsula. She liked them, too, and, when I suggested Snow Hill, Maryland, as the place, she enthusiastically agreed. Maryland was then the Gretna Green of the Mid-Atlantic States where marriages were performed with a minimum of fuss and feathers. Neither of us wanted a formal wedding. The simpler the better.

So, with our good friend, Robert G. "Bob" Hudson, as a chaperon, we drove down in late March of 1947 and obtained our marriage license without difficulty. We learned, however, that only a preacher could officiate in Maryland. Justices of the peace did not have such privileges. We had set April 10, 1947, for our wedding day, so, while I was in the vicinity, I telephoned to make an appointment. I do not recall which denomination I called first, but I immediately was asked, "Have either of you been divorced?" When I replied that both of us had, the response was, "It is against the policy of my church to remarry anyone who has been divorced." I thanked him and tried the next one. The result was the same. I talked by telephone with gentlemen of the cloth who were Episcopalians, Lutherans, Methodists, Presbyterians, Unitarians, and so on, not only in Snow Hill but elsewhere in Worcester and Wicomico Counties. I think that was the lineup, but the answer was invariably the same. Finally, in despair, I blurted out, "How then does one get married in Maryland?" After a slight hesitation, a scornful voice said, "Maybe John Ditto will marry you," and the speaker cradled his phone. Inquiry revealed that the Reverend John Ditto was a Baptist minister in Pocomoke City, down near the Virginia line. I called him at once, and he had no compunctions about divorce. I told him we had our license and asked him what else I should bring. His laconic reply was, "Just the girl and a ring." I joyfully thanked him, and we arranged for the ceremony to take place at his home between 2:00 and 3:00 PM on April 10.

So Snow Hill was out, but perhaps we could stay there on our wedding night. There was a small old-fashioned place, the Outen Hotel, in what was then a quiet little town, and it had a spotless dining room, excellent food, and a polished staff of white-coated black waiters. The atmosphere was much like other restaurants of the old South I had visited. Maryland had been a slave state before the Civil War, but it remained loyal to the Union. During our early field work on the Peninsula, long before Isabelle arrived at the zoo, we would occasionally see a restroom at a service station or elsewhere that had not yet been painted out, and which read "Whites Only."

Younger people of today have no conception whatsoever of the difficulties which existed until relatively recently. The sexual revolution was still far in the future at the time Isabelle and I were married. Fornication is commonplace nowadays, and few pay attention to it unless there is a pregnancy. Not too long ago, however, being caught sleeping with a woman, other than one's wife, was a serious matter, a felony in some states. Many laws were strict and penalties could be severe. We had to be very circumspect, and that is why we asked Bob Hudson to be our chaperon. He and I occupied the same room and Isabelle was by herself in the hotel where we stayed while we were en route to Snow Hill. When we traveled south on April 9, however, we stopped at the old Centreville Hotel, and that night we decided to take a chance and save the price of an extra room. I registered us as "Mr. and Mrs." After all, I had our license in my pocket, and a phone call to the Reverend Ditto would confirm our appointment with him on the morrow, just in case someone asked. No one did, After all, we were not a pair of eloping kids. I was 38 and Isabelle a few years older.

Because we had ample time to reach Pocomoke City on the 10th and we were both inveterate naturalists, we decided to take both field and dress clothes with us. We drove south in the morning and stopped at Wye Mills to see and photograph the enormous, very old, and historic white oak tree. We continued through Easton and Cambridge and then to the Gum Swamp, a small sphagnum bog near the present Blackwater Wildlife Refuge. There we were astounded to hear the unmistakable call of the carpenter frog, which never previously had been recorded from Maryland. There were several males in chorus. It was with real eagerness that I donned my old clothes, pulled up my boots, and waded into the bog. As soon as I did, the frogs became silent, but eventually I sighted my quarry. When I moved to within grabbing distance, however, they all vanished into the moss. Based on past experience I stood stock still and, presently, a head popped up above the surface. The behavior was exactly the same as I had witnessed and exploited many times while showing visiting herpetologists carpenter frogs in the New Jersey Pine Barrens. I quickly caught two specimens, which are now in the collection of the American Museum of Natural History, and which formed the basis for a short published note that appeared later the same year in "Maryland, A Journal of Natural History." Ever afterward Isabelle teased me by saying that I always remembered our anniversary date because of the frogs.

After wandering around in the bog for a short time, during which I saw a number of other "herps," I changed back into my "civies" (civilian clothes), as we called them in those days. We drove to Salisbury, where we had lunch and I bought an orchid for my darling. (She later pressed it, and it still remains in our "wedding book" after all the many intervening years).

Finding the Reverend Ditto's house in Pocomoke City was easy. He was ready and waiting for us. He was the only witness. He read the text for the marriage ceremony, told me

to put the ring on Isabelle's finger, and then to kiss her. I gave him the twenty-dollar bill he requested, and that was that. Ten minutes at the most. It was the start of an extraordinarily happy partnership that lasted until "Death do us part."

After offering our thanks to the Reverend Ditto we drove to Snow Hill. It was a heady ride, not only because we had just been married, but also because we were driving my brand new Oldsmobile sedan. It was one of the first to come off the line after the hiatus during and after World War II when new cars were virtually impossible to get. We stopped to admire the bald cypresses and other vegetation of the Pocomoke River basin, and to do a little smooching.

At Snow Hill we received an unexpected shock, but which was followed by a touching gesture of great kindness. I had carefully prepared for our wedding in advance but I had not made hotel reservations. Surely, it would not be crowded in early April. It was full! No vacancies. What was worse, the lovely old dining room was closed. There had been recent labor troubles caused by agitators from the north. A union? The employees went on strike and Mr. Outen, the owner manager, decided to abandon his marginally-profitable food service and concentrate on the hotel business. After all, he owned a diner right next to the hotel, and his guests could eat there. He was on the desk in person, and when he noted our obvious great disappointment, looked at Isabelle's orchid, and I told him we had just been married, he took pity on us. His home, almost an antebellum mansion, was right across the street. He escorted us there, showed us into a beautifully furnished guest room with a private bath, and told us it was ours for the night -- for free! Perhaps he was impressed by our radiant but dignified appearance. No matter what his reasoning was, he provided us with a splendid bridal suite for the night. We had to eat our wedding supper, however, while seated on stools along the counter of the diner. We were too happy to care.

Mr. Outen had trusted us, who were two complete strangers, and had given us a key to his beautiful home that contained innumerable antiques and other treasures. How could anyone beat that for southern hospitality!

We were soon to realize that we were pair bonded in the true biological sense of that term. Our lives seemed suddenly to be all ahead of us. We were to be constant companions, lovers, and devoted pals for almost 30 years.

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Cepaea nemoralis (Gastropoda: Pulmonata) in Maryland

Clement L. Counts, III and Caroline K. Weissman

Cepaea nemoralis (Linné 1798) is native to central and western Europe (Pilsbury 1939; Burch 1960, 1962). The species is reported to have been introduced into California, Colorado, Maryland, Massachusetts, New York, Pennsylvania, Tennessee, Virginia, Wisconsin, and Ontario (Burch 1960). The shell of *C. nemoralis* is distinctive from those of native Maryland snails by having approximately five whorls of a yellow, olive or red color usually having one to five reddish-brown spiral bands. The whorls are rounded with an ovate to lunate aperture with the apertural lip of adults being reflected and colored dark brown to almost black.

A single specimen of *Cepaea nemoralis* (UMES 3250) was collected near Frederick, Frederick County, Maryland on 10 April 1993 by Mr. David J. O'Neill of the University of Maryland Eastern Shore. It was taken from the west bank of the Monocacy River approximately 200 meters north of Route 40. The specimen is pale yellow with three narrow chocolate brown bands above the periphery and two wider bands basally. This specimen represents the third occurrence of *C. nemoralis* in the State of Maryland. Abbott (1950) indicated that *C. nemoralis* was present in Maryland without giving precise locality data. Reed (1964) noted that F. Wayne Grimm started a colony of 20 to 30 *C. nemoralis* in his backyard at Catonsville, Baltimore County, with individuals taken from a population at Burlington, New Jersey. All the shells were found in the fall of 1959 in mole and shrew runs and in a subsequent search of the area in September 1964 no specimens were found (Reed 1964). Grimm (1971) reported *C. nemoralis* as being deliberately introduced to Frederick County from Warm Springs, Virginia in July 1969.

The oldest reported colony of *Cepaea nemoralis* in North America was established by W. G. Binney in 1857 at Burlington, New Jersey. He reported that he imported 100 living specimens from Sheffield, England, and released them into his garden at Burlington (Pilsbury 1939). Pilsbury (1939) reported that the colony was still thriving but was confined to the town and none could be found in the surrounding countryside. Burch (1960) noted that *C. nemoralis* is eaten by Europeans and have been reported to be garden pests. We found no reports of *C. nemoralis* occurring as a pest species in Maryland. Given the report of Reed (1964) on the survival of the Baltimore County population, the present population at Frederick merits further investigation to determine if *C. nemoralis* has become established in the terrestrial molluscan fauna of the state.

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Summer Decline of Bird Song in North-central Maryland

Haven Kolb

Abstract

The summer decline in singing of 23 species of birds was monitored during July and August of 5 consecutive years. The decline in these species was found to fall into 4 patterns: (1) species in which song persisted during the period, though at reduced rates and intensities; (2) species in which decline was mostly in July; (3) species in which decline was mostly in August; and (4) species in which early July decline was followed by an August revival. Comparisons are made with previous studies in the northeastern states.

Introduction

Everyone notices the first robin song in spring. And all who have any real interest in birds know that Carolina wrens may be heard singing in any month of the year, that mockingbirds often have a fall song, and that birds, in general, sing less as summer progresses. But there seems to have been rather little interest in actually documenting decline of bird song.

Partly this may be due to summer lassitude and the attraction that early shorebird migration has for bird observers. However, I believe that it may rather be attributed to the need for continuous attention. When it is the beginning of song that is of interest, one notes the first song from a given species and that is usually that. To note the last song, however, one must continue attention to determine that the song heard on a given day really is the last; and such sustained attention is difficult to maintain.

Nevertheless, a few ornithologists have investigated this matter. The earliest that I have encountered was Bicknell (1844-1885), who, in a general study of bird song, noted that "birds in full voice while undergoing their second semi-annual moult ... appear to be uncommon, perhaps exceptional..." and then presented remarks on several late-summer singers. The study of Baerg (1930) was also a general one, but Fry (1916), Vaurie (1946) and Saunders (1948a) all focussed on late summer decline and cessation of song, though their methods of observing and recording varied. Except for that of Baerg in Arkansas, all of these studies were conducted in a rather small part of the northeastern United States: Pennsylvania, New York, and Connecticut.

Method of Study

During the summers of 1977 through 1981 I noted daily during the months of July and August all species of birds from which songs were heard in northwestern Baltimore County, Maryland. The area in which observations were made was the 2.5 hectares of my own property near Beckleysville plus perhaps 20 ha adjacent, mostly northeastward to the shore of Prettyboy Reservoir. About 2 ha of the area had been cultivated some 25 or so years before the study and had been modified with lawn, garden, orchard, and shrubbery around two residences. About 3 ha supported old-growth, mostly oak (*Quercus*) forest on hillsides that had probably never been cultivated. The remainder was land taken out of cultivation about 1930 when Prettyboy Dam was being constructed; it had developed a cover of pine (*Pinus virginiana*) with a rather thick understory of deciduous shrubs and young deciduous trees.

On a prepared form I noted each day each species from which song was heard during that day. In 1977 recording was discontinued on August 21; in all other years the records continued through the end of August. During the 300 days of the study I was absent from the study area only three days.

Within the limited area of the study, singing by 38 species was recorded during the five years. Additional species were sometimes heard but were not entered into the data set because previous experience in the area had indicated that they were rare or otherwise likely to produce only sporadic records. After the data had been gathered it was found that 15 of the 38 were present on fewer than 4 of the 5 years or were represented by transient individuals only. These (examples: Acadian flycatcher [*Empidonax virescens*], Kentucky warbler [*Oporornis formosus*], song sparrow [*Melospiza melodia*]) were removed from the data set.

I did not make any counts of the number of individual singers of a given species resident on the area nor the number of songs per given unit of time. Further, my data do not involve the quality and completeness of the singing, both of which are undoubted factors in the summer decline of song.

Results

The combined results of the five year study are shown in Figure 1. On the diagram a shaded block indicates that on that date at least one full song was heard in at least one year; lack of shading indicates that no song was heard in any year on that date. Thus the shaded blocks are unequal; one may indicate song on that date in each of the five years and another in only one year. Therefore, the figure does not indicate the consistency of song from year to year. However, it does tend to smooth out vagaries introduced by the daily and annual shiftings of meteorological conditions. Nor does it show the decline in quality and completeness of songs that is characteristic of late summer singing.

The great disparity among species in summer song decline is immediately evident.

First, there are the persistent singers: mourning dove, yellow-bellied cuckoo, eastern wood pewee, white-eyed vireo, red-eyed vireo and northern cardinal.

Second, there is a group that shows a clear decline in July: great crested flycatcher, eastern phoebe, veery and ovenbird. For the veery and ovenbird there is a complete cessation of song before the end of the month.

Third, for a larger group: Carolina chickadee, eastern tufted titmouse, gray catbird, American robin, wood thrush, common yellowthroat, scarlet tanager, indigo bunting, rufous-sided towhee and chipping sparrow, the decline is mostly in August.

Fourth, the yellow-throated vireo and Baltimore oriole have their principal song period in the months before this study began. Both also, after a short interval of silence (11 days for the former and 15 for the latter in my data) sing again.

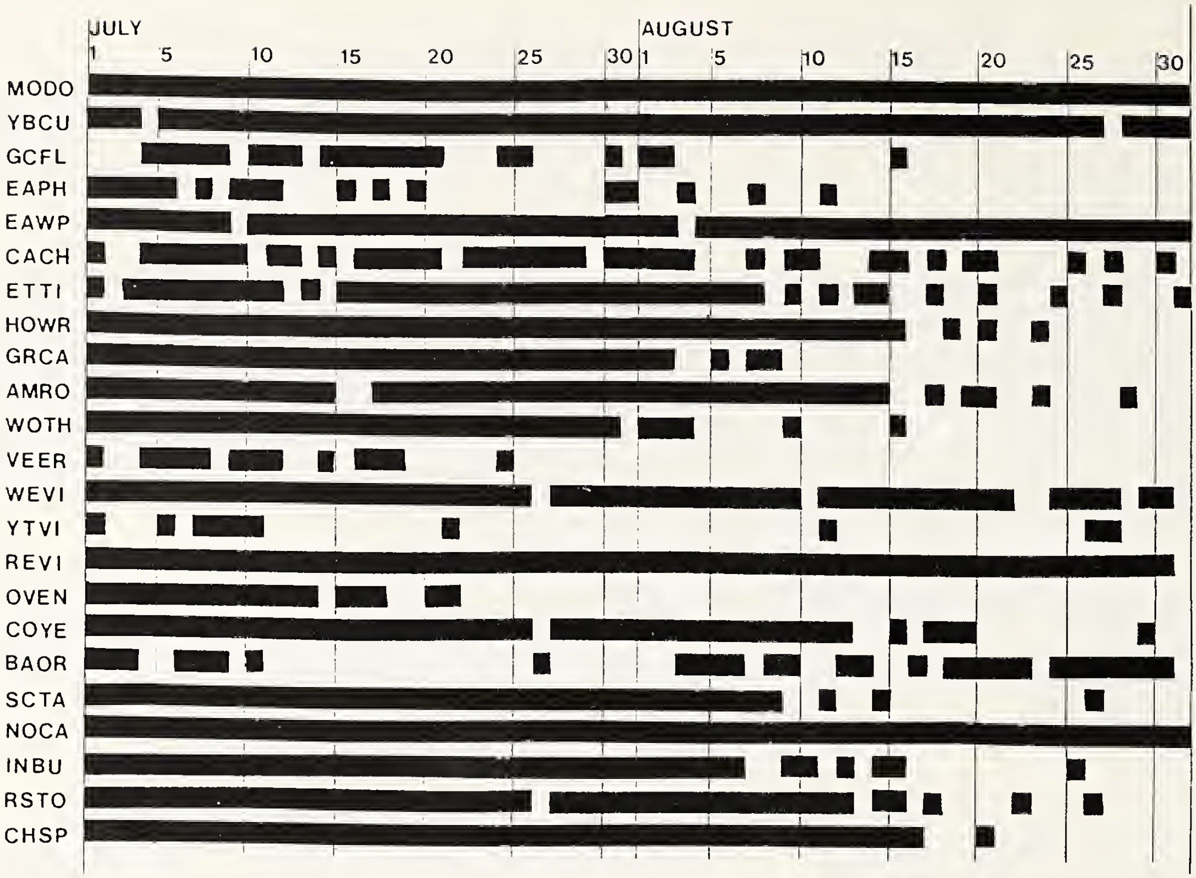

Figure 1. Record of summer song of selected species of birds at Beckleysville, Maryland, 1977-1981. The abbreviations of species names are those of the Bird Banding Office of the U.S. Department of the Interior as follows: MODO, mourning dove (*Zenaida macroura*); YBCU, yellow-billed cuckoo (*Coccyzus americanus*); GCFL, great crested flycatcher (*Myiarchus crinitus*); EAPH, eastern phoebe (*Sayornis phoebe*); EAWP, eastern wood pewee (*Contopus virens*); CACH, Carolina chickadee (*Parus caroliniensis*); ETTI, eastern tufted titmouse (*Parus bicolor*); HOWR, house wren (*Troglodytes aedon*); GRCA, gray catbird (*Dunetella carolinensis*); AMRO, American robin (*Turdus migratorius*); WOTH, wood thrush (*Hylocichla mustelina*); VEER, veery (*Catharus fuscescens*); WEVI, white-eyed vireo (*Vireo griseus*); YTVI, yellow-throated vireo (*Vireo flavifrons*); REVI, red-eyed vireo (*Vireo olivaceus*); OVEN, ovenbird (*Seiurus aurocapillus*); COYE, common yellowthroat (*Geothlypis trichas*); BOAR, northern (Baltimore) oriole (*Icterus galbula*); SCTA, scarlet tanager (*Piranga olivacea*); NOCA, northern cardinal (*Cardinalis cardinalis*); INBU, indigo bunting (*Passerina cyanea*); RSTO, rufus-sided towhee (*Pipilo erythrophthalmus*); CHSP, chipping sparrow (*Spizella passerina*).

Discussion

In general, the results of this study agree with those of the previous ones cited above. However, I eliminate from further consideration the study of Baerg (1930) on the basis of geographical distance and latitudinal disparity. The report of Bicknell (1884-1885) is essentially anecdotal, without tabular or graphic data, though many of his remarks have been corroborated in later, more systematic studies.

In my data the only species not represented in the more northerly studies is the Carolina chickadee. However, it might be expected that it would be similar in song period to the closely

related black-capped chickadee (*Parus atricapillus*). Fry (1916) indicated that on Long Island, New York, that species sang to August 10, the end of his study period. Saunders (1948a) in 15 years of observations in Cattaraugus County, New York, gave August 16 as last date and in 6 years of observation in Fairfield, Connecticut, August 15. It may be doubted that my date of August 30 for the Carolina chickadee represents a real difference in the two species.

Of the species in my group of persistent singers, the red-eyed vireo receives the most support from other observers -- as far back as Bicknell (1884-1885): "A most untiring vocalist..." For the dove and the cuckoo, Saunders (1948a) provides the last dates of August 21 and 22 respectively and for the white-eyed vireo August 17 -- all of these from Connecticut. Vaurie (1946) implies that he heard doves until the end of his observation period on September 4. For the wood pewee Vaurie (1946) wrote, "Heard on 13 days...These days were scattered throughout the whole period [July 20 to September 4] and no pattern is evident." Also for the wood pewee Fry (1916) in his chart shows song through the end of his period of observation, August 10. The cardinal is mentioned in only one of the other cited studies, Vaurie (1946). Observing during just one summer in Berks County, Pennsylvania, he gave August 23 as the last date of song. All of the notes in this paragraph are not inconsistent with my first group, persistent singers, but my data show more continuity in the singing than might be derived from the other investigators' results.

My second and third groups most clearly show the summer song decline that leads to cessation. They differ from each other only in the timing of the decline, but the differentiation of the groups is supported by the data of my predecessors. For the four species of my second group, last dates in July are given, except August 6 for the crested flycatcher and August 13 for the phoebe, both in Connecticut (Saunders 1948a).

For the species in my third group, the published last dates are in August, with three exceptions: Vaurie (1946) is the only one of the authors who mentions the tufted titmouse, "They never sang but kept up a moderate amount of chatter on their visits." Fry (1916) had last dates of July 22 for the common yellowthroat and July 28 for the scarlet tanager. For the common yellowthroat, scarlet tanager, and rufous-sided towhee my data carry occasional song further into August that do those of the other investigators, but otherwise there is rather close agreement.

Finally, my fourth group really introduces a new subject: the revival of song after the breeding season. Saunders (1948b) treats this subject in detail. Though most of his paper is concerned with singing in September and later, he cites both the yellow-throated vireo and the Baltimore oriole for earlier revival. For the former he gives August 15 as the earliest date of revival. For the oriole he writes: "...In some years revival follows cessation so closely that I can only guess which dates are the last of the nesting singing and which are the first of revival...the beginning of revival averages July 24...The revived songs begin with ones that are short and curtailed, but they gradually pick up to full songs in mid-August..." My data for the vireo are not clear, but for the oriole they agree very well with Saunders.

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A Second Record of the Southern Bog Lemming, *Synaptomys cooperi*, from the Delmarva Peninsula

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Introduction

The southern bog lemming, *Synaptomys cooperi*, is a small rodent that occurs in Eastern North America from southern Canada southward through the mid-Atlantic states, including the southern Appalachians, and west to central Kansas and Nebraska. There are five recognized subspecies: *cooperi*, *gossii*, *helaletes*, *paludis*, and *stonei* (Wetzel 1955). Only *S. c. stonei* is known from Maryland (Paradiso 1969, Wetzel 1955). Paradiso (1969) gave six localities for this species in Maryland and concluded that it occurred throughout the state (Figure 1). The only record of this lemming from the Delmarva Peninsula was a specimen collected along the Pocomoke River by Poole (1943).

On 13 May 1993 we collected a single *Synaptomys cooperi* in Worcester County, Maryland (NCSM 7412). This is the second known specimen for the Delmarva Peninsula. It was collected in a field adjacent to Greenbrier Swamp Road, 1.1 mile N. of the intersection of that road and Old Furnace Road. We set out 110 snap traps on each of the nights of 13 and 14 May. The first evening a hard rain set off about 10% of our traps. The second night an animal, probably a raccoon (*Procyon lotor*), tampered with the traps, moving them, removing bait and springing over 90% of them. No other mammals were caught at this site.

Ecological Considerations

Our specimen was trapped in a field that had been timbered five-to-ten years previously. The field was 75+ acres in extent and supported sapling pines and other woody vegetation 1 to 1.5 meters in height (Figure 2A). Rodent runs were abundant beneath grasses and sedges but seemed limited to areas within 1 m of a 0.5 m wide ditch which ran perpendicular to the adjacent road. We noted the presence of cut sedges in the runways and standing cut stems along the ditch (Figure 2B), indicating the presence of some microtean rodent. The plant community was dominated by loblolly pine (*Pinus taeda*), sweet gum (*Liquidambar styraciflua*), sassafras (*Sassafras albidum*), Virginia sweet spice (*Itea virginica*), sweet pepperbush (*Clethra alnifolia*), red maple (*Acer rubrum*), wax-myrtle (*Myrica cerifera*), blackberries (*Rubus* sp), several species of *Smilax*, blueberries (*Vaccinium* sp.), soft rush (*Juncus effusus)*, and broom-sedge (*Andropogon virginicus* var. *glomeratus*).

The specimen captured by Poole (1943) was collected on 29 November 1941 about 6 miles southwest of Snow Hill, Worcester County, Maryland. The habitat was "deep sphagnum" among cypress swamps along the Pocomoke River. Poole was inspired to collect in the area by a verbal report of a *Synaptomys* skull being found in a barred owl (*Strix viria*) pellet in the same area. Our record is about 9.5 miles NNW of Poole's site, but still within the Pocomoke basin.

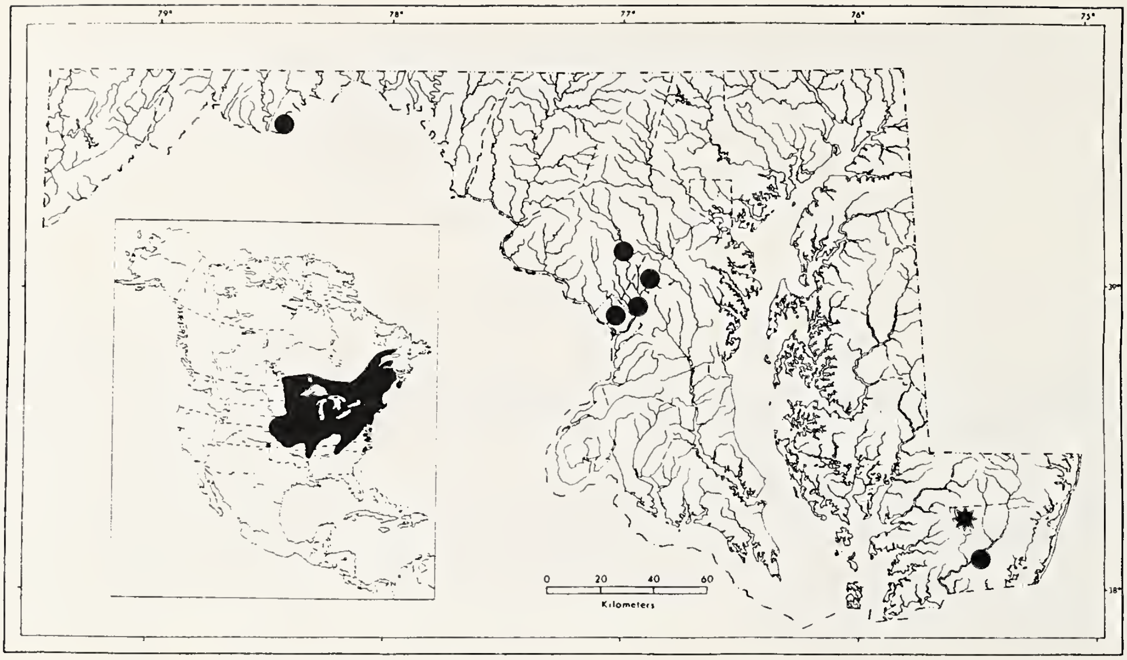

Figure 1. Distributional records of the southern bog lemming, *Synaptomys cooperi,* in Maryland and North America (inset). Record reported here shown as star (*). Localities given by Paradiso (1969) shown as solid circles (●). There are no reliable records for Delaware or the Delmarva Peninsula counties of Virginia.

In addition to the habitat described for our specimen and the sphagnum/cypress swamp site noted by Poole (1943), this rodent has been reported to occur in bogs, moist meadows, cane brakes, borders of marshes, pocosins, and various types of grasslands and fields. They are also known from young pine plantations, thickets, moist woodlands and orchards. It is clearly a species primarily of early successional stages in areas with, or adjacent to, damp or saturated soils. Because of the wide ecological tolerance of this rodent it is difficult to understand why it is not more widely-known in this portion of its range.

In 1782 there was a massive fire in the Pocomoke swamp. At night the glow from the burn could be seen as far as Philadelphia, 70 miles away (Stalter 1981). A second major fire swept the Pocomoke area and burned persistently for six months after a severe drought in 1931 (Beaven and Oosting 1939). Over 3,000 acres were burned. In the decades that followed these fires, there would have been extensive areas of open early succession habitats and the lemming population should have responded to this. In fact the sphagnum areas trapped by Pool in the early 1940's may have been habitats created by the 1931 fire.

The Pocomoke swamp was quite different prior to man's interventions and the above mentioned fires. The English botanist, Thomas Nuttall, who visited the swamp in 1809, wrote (in Tatnall 1940): "....It was filled with tall tangling shrubs thickly matted together almost impervious to the light...It was very wet; knee deep in sphagnum if you step off the bridges of wooden causeways. There were some open places called savannahs, but were literally ponds at this time of the year, but are dry in summer...on the edges of these ponds grew the cupressus disticha [*Taxodium distichum*]..." The open savannahs and sphagnum swamps Nuttall described

would seem to be ideal habitats for *Synaptomys*. Clear-cutting and other 20th century land management practices could provide habitats that are similar to, or perhaps even better-suited for *Synaptomys* than those present in the early 19th century.

Figure 2. A; habitat from which a single southern bog lemming, *Synaptomys cooperi*, was captured on 13 May 1993. Site is adjacent to Greenbrier Swamp Road, Worcester County, Maryland. B; *Juncus* stems presumed to have been cut by *Synaptomys* (same locality and date).

Despite the comment by Paradiso (1969) that *Synaptomys* occurs throughout Maryland, we believe that it may be more restricted, particularly on the Delmarva Peninsula. Although there has been little effort to census the small mammal fauna of the lower Delmarva, most studies that have been done have failed to yield this species. For example, in a fairly extensive trapping and barn owl pellet survey for small mammals in Somerset County, Maryland and in Kent County, Delaware (Lee 1973, Lee et al. 1972) and a trapping survey of Assateague Island, Maryland and Virginia (Handley and Paradiso 1965), no *Synaptomys* were reported.

This vole is notoriously difficult to collect. Despite considerable interest in the Dismal Swamp race, *Synaptomys c. helaletes*, it has been reported that no specimens were collected between 1898 and 1980 (Rose 1981). While this is not entirely true (we obtained several North Carolina records in the 1970's [Lee et. al. 1982]) the statement is basically correct. Clark et al. (1993) reported that in over 25,000 trap nights in habitats occupied by *Synaptomys* only three specimens were collected. These trap nights were combinations of standard snap traps and pit-fall traps. Field workers have found that *Synaptomys* are not attracted to bait but can occasionally be caught by placing traps across runways or by placing pit-fall traps along routes used by these lemmings. Even with extensive field work it may be decades before enough material from the lower Delmarva Peninsula accumulates to make detailed systematic comparisons between populations, and to understand the distributional limits of this lemming on the Atlantic Coastal Plain.

Systematics And Meristics

Poole regarded his specimen to be *S. c. stonei*, but provided no support for that subspecific identification. The specimen, which was deposited in the Reading Museum, is no longer available (D. Winkler pers. comm.) so it is not possible to confirm its subspecific status. No one working with the systematics of *Synaptomys* seems to have examined Poole's specimen (Paradiso 1969, Wetzel 1955), and it was not available during the earlier reviews and revisions of the genus (Howell 1927, Marriam 1896, Rhoads and Young 1897).

Our specimen was an adult female which weighed 25.5 grams. Its measurements, given in Table 1, show it to be smaller than expected for the Dismal Swamp race, *S. c. helaletes*, and within or below the lowest size limits of *S. c. stonei* from Prince Georges County, Maryland in general, New Jersey or the Southern Appalachians (see Wetzel 1955). However, its tail was longer that those of either race.

Webster (1992) and Clark et al. (1993) recently documented *Synaptomys cooperi* from the outer Coastal Plain of southeastern North Carolina. These records extended the range of *Synaptomys* 120 to 170 km south of the Dismal Swamp. Webster (1992) reported his single specimen to represent *S. c. helaletes*, but he provided no measurements or other information to support this. The three specimens discussed in Clark et al. (1993) represent the southernmost records for the species. Clark et al. (1993) were not convinced that their specimens were *helaletes* and suggested that the material represented a relict population of *stonei* or a population of intergrades between *stonei* and *helaletes*. Likewise we are unwilling to assign a subspecific designation to our single Delmarva specimen. Its small size suggests that it is of different origin, or at least has been long isolated from the populations known from west and north of the Chesapeake Bay.

Synaptomys c. helaletes, is not a particularly well-defined subspecies, and recent collections in North Carolina make the exact distribution of that race unclear. Wetzel (1955) found that of the 13 cranial measurements used to distinguish the various races of *S. cooperi*, eight did not demonstrate significant differences between *stonei* and *helaletes*. He also noted that no significant differences were seen in pelage between *S. c. stonei* and *S. c. helaletes*. While Wetzel (1955) chose to retain *helaletes* in his revision of the species, he noted that it "does not differ so greatly from the nearest form as do the other subspecies." He believed that its origin was directly from *S. c. stonei*.

Table 1. Summary of selected measurements (in mm) of *Synaptomys cooperi* (sources Paradiso 1969, Wetzel 1955, our data).

	stonei Prince Georges Co. n=5-6	*helaletes* n=10	Worcester Co. n=1
Total Length	127.4 (120-135)*	125.4 (1.9)**	120
Tail	21.2 (18-23)	20.0 (0.12)	24
Hind foot	19 (18-23)	19.6 (0.08)	18.5
Greatest length of skull	24.7 (23.4-24.9)	25.1 (0.20)	23.8
Zygomatic breadth	17.0 (16.5-17.5)	17.1 (0.22)	16.3
Interorbital constriction	2.9 (2.7-3.1)		2.5
Length of maxillary tooth row	7.5 (7.4-7.8)	7.6 (0.02)	6.5

* mean (and range)
** mean (and one standard error)

Zoogeography

The current distribution of several other mammals on the lower Delmarva Peninsula strongly suggest that their affinities are with populations from the Dismal Swamp area of eastern Virginia and northeastern North Carolina, rather than from populations north and/or west of the Chesapeake Bay. These taxa include the meadow vole (*Microtus pennsylvanicus nigrans*), the white-footed mouse (*Peromyscus leucopus leucopus*) and the star-nosed mole (*Condylura cristata parva*). These distributional patterns and the supporting literature were reviewed by Lee (1987). Similar scenarios of dispersal would also appear to apply to a number of reptiles and amphibians. While the subspecific identity of the one existing Delmarva specimen is not certain, it is likely that the southern bog lemmings on the lower Delmarva Peninsula had a similar zoogeographic history.

We postulate that during the late Pleistocene outer Coastal Plain populations of *Synaptomys cooperi* south of New Jersey were isolated from those on the adjacent Piedmont and Appalachian regions, and the formation of the Chesapeake Bay (perhaps as late as 5,000 BP) separated the present day Dismal Swamp and Delmarva populations. The southeastern North Carolina population became isolated by the large sounds and tidewater areas that formed as Pleistocene shorelines were drowned by rising sea levels. Whether or not the populations on the Delmarva Peninsula and southeastern North Carolina should be considered *helaletes* is not clear, but they are certainly remnants of a more widely distributed population that inhabited the outer Atlantic Coastal Plain during the late Pleistocene.

Acknowledgements

We thank Debra Winkler of the Reading Museum for searching for Poole's specimen, and the Maryland Department of Natural Resources for providing a permit to trap *Synaptomys* (SCO-14368). Jean Worthley identified plants from the trap site.

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Diacyclops virginianus, a New Species of Cyclopoida (Crustacea: Copepoda) from Goose Creek, Virginia

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Abstract

Diacyclops virginianus, new species (Cyclopoida) is described from the streambed of Goose Creek, Virginia. The species has highly reduced leg segmentation for the genus: both rami of legs 1 and 2 and the endopodites of legs 3 and 4 are biarticulate, while the exopodites of legs 3 and 4 are usually biarticulate with the distal articles partly divided. The species differs from all known congeners in this partial division of some rami of the swimming legs. Leg 5 is also unusual for the genus *Diacyclops* in having the proximal article fused to the somite and the armament of the distal article consisting of two slender setae. *Diacyclops virginianus* most resembles two rare and poorly described European species.

Introduction

North American limnologists historically have placed greatest emphasis on understanding biological processes in the lakes and rivers of the continent. During the past decade, increasing interest in other aquatic habitats such as small surface wetlands, ephemeral waters, and subterranean waters including the hyporheic zone of streams has augmented the rate of discovery of previously unknown species of invertebrates. For instance, 39 of the 45 new taxa of copepods discovered in North America since 1980 have been collected from such non-lacustrine sites (Reid 1992c). Copepods are small crustaceans that have been very successful in colonizing aquatic and semi-aquatic habitats of all sorts. For several years, Dr. Margaret A. Palmer and associates from the University of Maryland-College Park have conducted intensive ecological investigations of the meiofauna, the smaller metazoans, inhabiting the sediments of the streambed of Goose Creek, Virginia. It is not surprising that a byproduct of these investigations has been the discovery of several new species of copepods (Reid 1992a,b). I describe herein the fifth new species found in the creek.

Goose Creek is a fourth-order, relatively undisturbed stream in the Potomac River drainage basin. The creek has been more fully described elsewhere (Palmer 1990a,b, Vadas 1992). The specimens were sorted from samples of streambed sediments that had been preserved in 5% buffered formalin, and transferred to 70% ethanol for permanent storage. Habitus drawings were made from specimens in lactic acid at magnifications of 600 X; dissected body parts were permanently mounted in commercial polyvinyl lactophenol (PVL) or CMC-10 media and drawn at 1000 X or 1500 X using an oil immersion lens. The specimens are deposited in the collections of the Division of Crustacea, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution (USNM).

Systematics of the Copepoda, especially at the genus level, traditionally has relied heavily on the structure of the fifth legs, which are usually strongly modified and tend to be among the most conservative morphological features. The structure and armament of the fifth leg of the new species from Goose Creek are unusual and render the generic assignment problematical. I have tentatively placed it in *Diacyclops* and discuss known variations in the structure of the fifth

leg within that genus, as well as other issues regarding the present diagnosis of *Diacyclops*, following the species description.

Taxonomic Section

Family Cyclopidae Burmeister, 1834
Genus *Diacyclops* Kiefer, 1927, 1928, emend. Morton, 1985, Reid et al., 1989
Diacyclops virginianus, new species
Figs. 1-3

Material.-- Holotype female, fully dissected on slide in PVL, Sample T4 Dam 31 coarse, May 1992, USNM 259513. Allotype male, Sample T4 Dam 32 midchannel, May 1992, USNM 259514. Paratypes: 1 female, fully dissected on slide in CMC-10, Sample T4 Dam 31 midchannel, May 1992, USNM 259515; 1 female, Sample T4 Dam 32 coarse, May 1992, USNM 259516; 1 female, 2 males and 1 copepodid, Sample T11 D31 II, June 1992, USNM 259517. All from Goose Creek, Loudoun County, Virginia, 38°57'N, 77°45'W; coll. M. A. Palmer. Undissected specimens in 70% ethanol.

Description of female.--Length, excluding caudal setae, of holotype 410 µm; lengths and other dimensions of holotype and three paratypes given in Table 1. Preserved specimens colorless. Habitus (Figure 1a) cyclopoid, body little sclerotized, widest at cephalosome and pediger 2 in dorsal view. Lateral margins of prosomites rounded, smooth. Genital segment (Figure 1a-c) about 1.2 times broader than long, anterior half expanded, much produced ventrally, leg 5 (Figure 1 b-d) partly obscured in undissected specimens. Genital field (Figure 1c) bilobate, anterior and posterior lobes indistinct and more or less enlarged in different specimens; pore-canal short, broad, sclerotized, directed anteriorly; lateral canals more or less horizontal. Hyaline fringes of posterior margins of genital segment and two succeeding urosomites smooth. Anal somite (Figure 1a,e,f), posterior margin naked dorsally and spinose ventrally; anal operculum rounded, sclerotized, reaching or slightly exceeding lateral posterior margin of anal somite. Caudal ramus (Figure 1a,e,f) about 1.9 times longer than broad, medial surface hairless, lateral surface ornamented only with two or three small spines anterior to insertion of lateral seta and five or six slightly larger spines (best visible in lateral view) anterior to insertion of lateralmost terminal seta. Lateral seta inserted slightly posterior to midlength of caudal ramus. Terminal caudal setae with fine plumage, dorsal and lateral setae naked. Lengths of caudal setae of holotype given in Table 1.

Antennule (Figures 1a, 2a) of 11 articles, shorter than cephalosome; article 5 with spine, articles 8 and 10 each with sensillum (spine and sensilla indicated by arrows in Figure 2a); no hyaline membrane visible on distalmost articles. Antenna (Figure 2b) lacking exopodite seta and one of two setae normally present on anterodistal margin of article 1, this article with few small spines visible on proximal part of posterior margin; article 3 with six setae. Labrum (Figure 2c) with many small irregular teeth. Mandible (Figure 2d) with palp bearing one short and two long setae, length of long setae on undissected paratype about equal to length of mandible. Maxillule (Figure 2e) with four large terminal and subterminal teeth, three distal setae of palp short. Maxilla (Figure 2f) with two small teeth on beaklike extension of article 3; tip of maxilla of holotype broken in dissection and good mount not obtained from other dissected specimen,

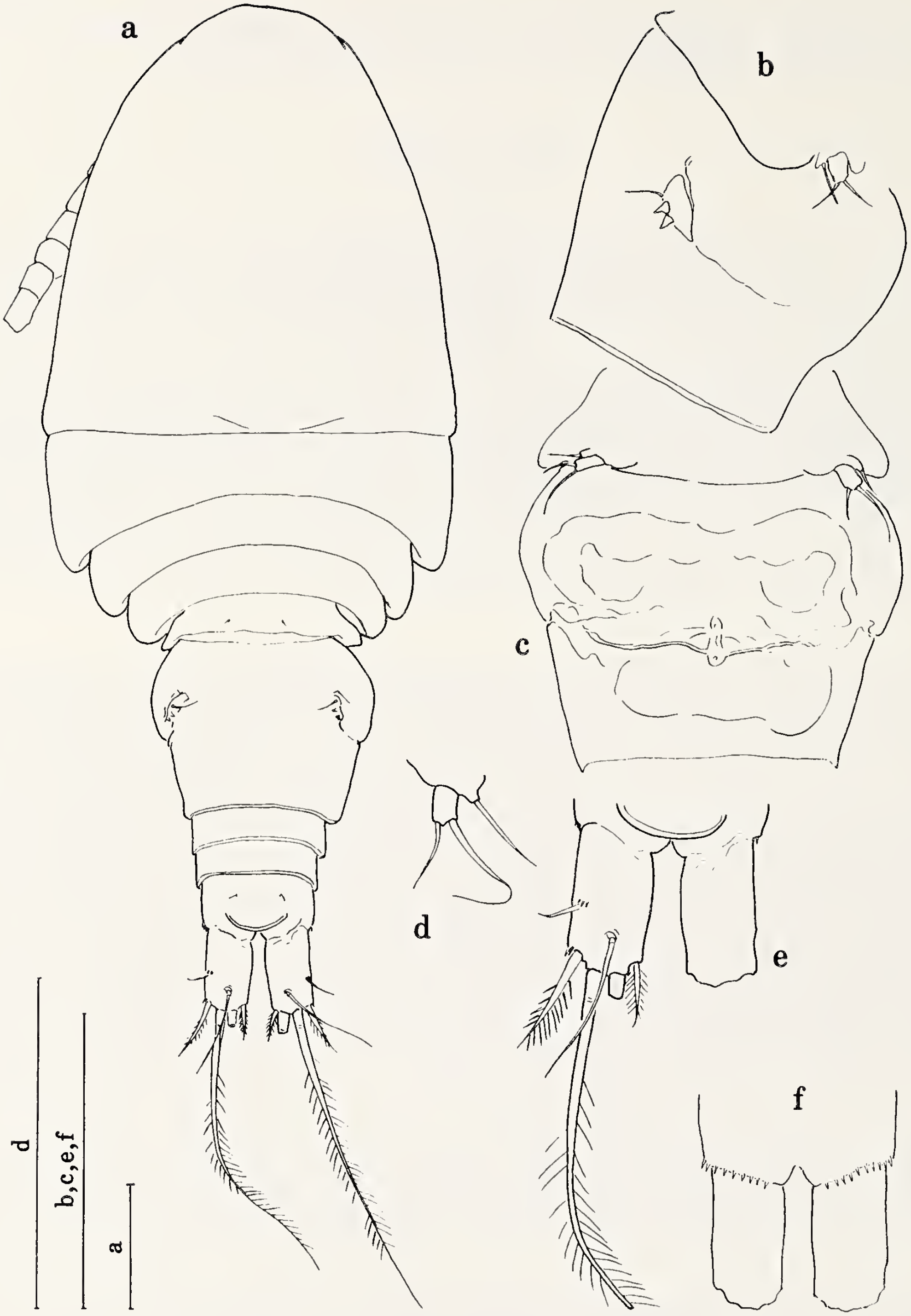

Figure 1. *Diacyclops virginianus*, new species, female; a, d-f, Holotype, USNM 259513; b, c, Paratype, USNM 259515: a, Habitus, dorsal; b, Pediger 5 (part) and genital segment, right lateral; c, Pediger 5 and genital segment, ventral; d, Right leg 5; e, Posterior part of anal somite and caudal ramus, dorsal; f, Posterior part of anal somite and caudal ramus, ventral. Figure 1a-c, e, f drawn at 600 X from whole specimen in lactic acid; Figure 1d drawn and details of Figure 1e, f verified at 1000 X from dissected specimen in PVL; all scales indicate 50 μm.

however distal articles of maxilla, observed on undissected female paratype and male allotype, normal for family (cf. *Diacyclops sororum* Reid, 1992b). Maxilliped (Figure 2g) short, composed of normal four articles, article 2 with only one seta and with two rows of small surface spines. Swimming legs 1 and 2 (Figure 2h,i) each with biarticulate rami. Legs 3 and 4 (Figure 3a,b) each with biarticulate endopodite, exopodites also biarticulate but with distal articles each divided by partial suture on lateral margin. Partial division of these articles distinct on both anterior and posterior surfaces between proximalmost and next distal spines, extending to about midline of each article, and marked on leg 3 also by transverse row of spines on anterior surface. Couplers of all legs without ornament; coupler of leg 2 broken in dissection but similar to coupler of leg 3 in shape. Leg 1 basipodite little expanded medially; medial expansions of legs 2-4 basipodites lobate, haired. Leg 1 with short serrate spine on medial expansion of basipodite, slightly longer than endopodite article 1. Spine formula of distal articles of exopodites, considering semi-divided distal articles of legs 3 and 4 as one article, 3,4,4,4; seta formula 5,5,5,5. Spines of leg 4 exopodite smaller than spines of more anterior legs. More distal setae of posterior legs stout basally, with thin whiplike tips. Leg 4 endopodite article 2 about 1.5 times longer than broad, with two stout serrate terminal spines, medial spine longer than lateral spine.

Table 1. Measurements of *Diacyclops virginianus*, new species.

	Females				Males		
Total length	410*	380	312	307	260**	310	280
Caudal ramus							
Length	28	28	28	28	28	26	23
Breadth	15	15	15	14	14	13	13
Seta 1	10	9	13	10	8	9	8
Seta 2	b	b	148	b	182	162	170
Seta 3	95	105	98	115	94	83	97
Seta 4	19	17	18	18	15	17	17
Dorsal seta	37	34	35	35	28	31	30
Insertion ls	16	16	16	17	15	17	17
Leg 4							
Enp2, Length	23	25	27	25	23	22	23
Enp2, Breadth	15	16	15	15	15	15	15
MTS	17	16	19	17	14	15	17
LTS	12	12	13	13	12	12	12

Note: Dimensions are given in µm; Seta 1-4, medialmost to lateralmost terminal caudal setae; Enp2, endopodite article 2; Insertion ls, distance along lateral margin of caudal ramus from anal somite to insertion of lateral seta; MTS, medial terminal spine; LTS, lateral terminal spine; b indicates both setae broken; * indicates holotype; ** indicates allotype.

Leg 5 (Figure 1b-d), article 1 fused to pediger 5; article 2 distinct. Article 1 with seta on lateral expansion. Article 2 with medial terminal seta and longer lateral terminal seta, both setae with fine hairlike tips. Lateral terminal seta about twice width of medial subterminal seta at base. Because of fineness of tips, length of all setae difficult to determine except by means of phase-interference microscopy, setae appearing much shorter by conventional microscopy, as in Figure 1b,c.

Description of male.--Length of allotype 260 µm; measurements of allotype and male paratypes given in Table 1. Habitus (Figure 3c) except for normal sexual dimorphism, antenna, mouthparts, swimming legs and leg 5 like corresponding structures of female in two of three specimens. In allotype and one paratype, legs 3 and 4 exopodites as in females; in one paratype, distal articles of legs 3 and 4 exopodites fully divided, exopodites thus triarticulate. Caudal ramus 2 times longer than broad, ornamented with single spine anterior to insertion of lateral seta and several smaller spines at base of lateralmost terminal seta; caudal ramus and setae otherwise similar to those of female. Lengths of caudal setae given in Table 1.

Antennule (Figure 3d) reaching past posterior border of cephalosome, geniculate, of 17 articles, two distalmost articles indistinctly divided. Visible esthetascs short, narrow, two on article 1 and one on article 9 (indicated by arrows in figure).

Leg 6 (Figure 3e) consisting of large subrectangular flap bearing three setae, all setae shorter than succeeding urosomite.

Etymology.--Named for the state in which the specimens were collected.

Ecology.--The specimens were collected during two time periods (T4 and T11), each after the stream flow had returned nearly to normal (less than 5 m^3/s) following a flood pulse. All specimens were found in a single short reach of the creek near a debris dam, in coarse sands or in midchannel sediments of the creek bed.

Discussion.--Partial division of some articles of the swimming legs like that in most specimens of *Diacyclops virginianus* has not to my knowledge been found in other species of the genus. The lateral divisions are so distinct in *D. virginianus* that the number of articles might be miscounted; care should be taken to check the medial margin of the article, which is slightly indented but not divided. Traces of ancestral divisions certainly can be seen on the swimming legs of many species in the Cyclopidae. These traces however consist of homologies in setae and spines, or of a small spiniform structure on the lateral margin marking the original distal corner of an article. Such spines are present in *D. virginianus* on the distal articles of the endopodites of legs 2 and 3.

Few known species of *Diacyclops* have most or all rami of the swimming legs biarticulate. Two species have legs 1-4 with all rami biarticulate except for the triarticulate exopodites of legs 3 and 4. These are *Diacyclops imparilis* Monchenko, 1985, from the Republic of Georgia, and *Diacyclops yezoensis* (Ito, 1954; male described by Ishida 1992), from Japan and Alaska. The divisions between articles are complete in both species, and no variation in the leg structure has been reported. These species also differ from *D. virginianus* in having large triangular anal opercula and in other details. *Diacyclops minutissimus* sensu Petkovski 1954,

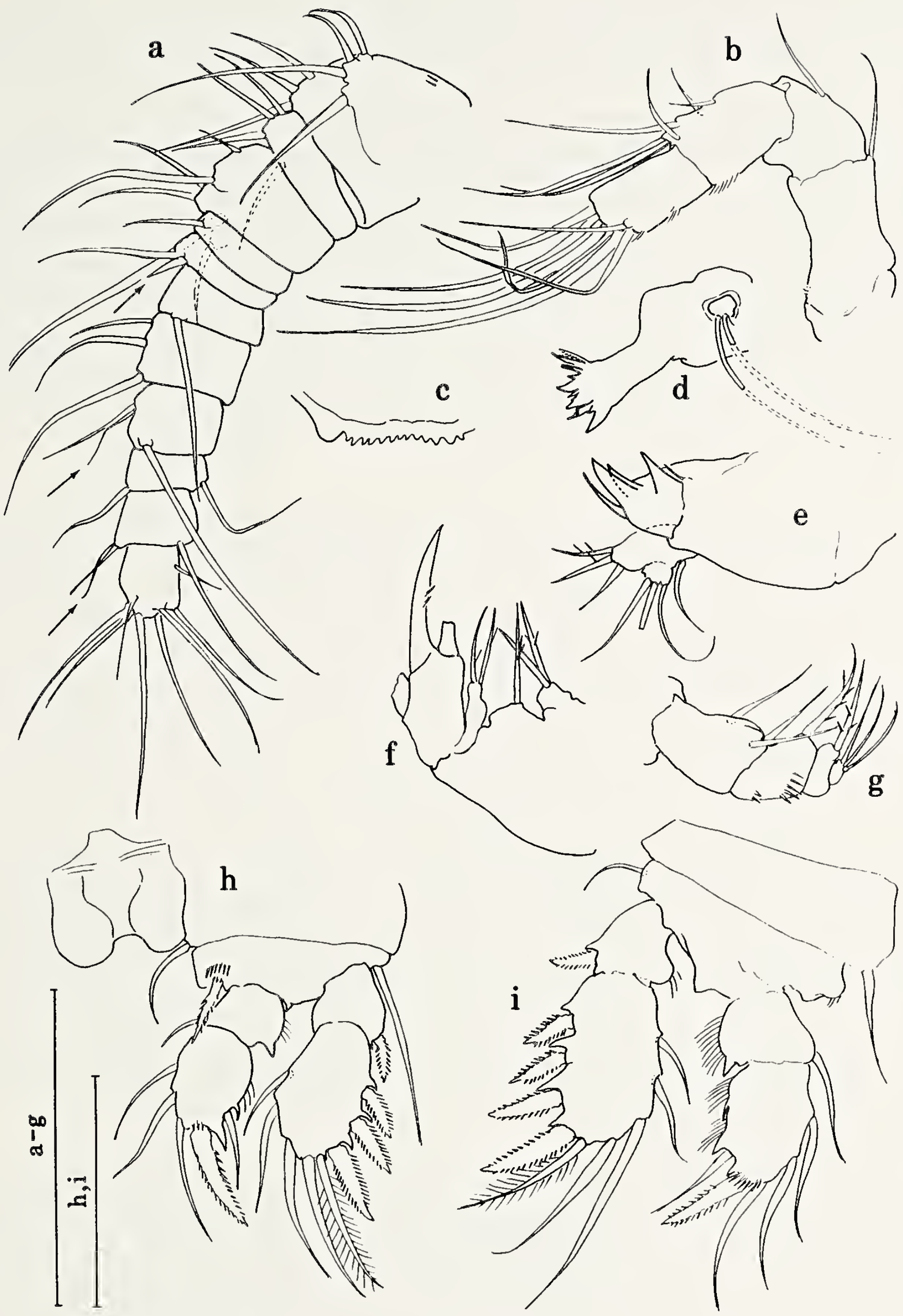

Figure 2. *Diacyclops virginianus*, new species, female; a, b, d-f, h, i, Holotype, USNM 259513; c, g, Paratype, USNM 259515: a, Antennule; b, Antenna; c, Labrum, left corner missing; d, Mandible (length of setae of palp estimated from paratype, USNM 259516; e, Maxillule; f, Maxilla (distalmost articles missing); g, Maxilliped; h, Leg 1 and coupler, anterior; i, Leg 2, anterior. Figure 2a, b, d-f, h, i drawn at 1500 X from dissected and mounted specimen in PVL; Figure 2c, g drawn at 1000 X from dissected and mounted specimen in CMC-10; both scales indicate 50 μm.

from Yugoslavia, although incompletely described, apparently has fully biarticulate rami of the swimming legs, as well as a large, bluntly triangular anal operculum. This species was transferred to the genus *Diacyclops* by Monchenko (1985) and has not yet been formally named.

One of the unusual features of the structure of the leg 5 of *D. virginianus* is the fusion of the proximal article to the body somite. Fusion of the proximal article and the somite is not unknown in *Diacyclops*, either as a permanent or a variable feature: the article and somite vary from distinct to fused in *Diacyclops nanus* (G. O. Sars, 1863, after the redescription of Gurney 1933), and are invariably fused in *Diacyclops abyssicola* (Lilljeborg, 1901, after the redescription of Kiefer 1926), *Diacyclops michaelseni* (Mrázek, 1901, after the redescription of Lindberg 1949) [=*Diacyclops skottsbergi* (Lindberg, 1949)], *Diacyclops mirnyi* (Borutzky and Vinogradov, 1957), and *D. yezoensis*. In some species the division between the proximal and distal articles of the leg may be indistinct, although none of the few specimens of *D. virginianus* shows this feature. This condition is variable in *D. mirnyi* and invariable in *D. abyssicola*.

The more important feature is the nature of the two terminal appendages on the leg 5 distal article. Most species of *Diacyclops* have a medial subterminal spine rather than a seta, and indeed the presence of this spine is the fundamental feature of the generic diagnosis (Kiefer 1927, 1928, Morton 1985, Reid et al. 1989). However, *D. minutissimus* sensu Petkovski 1954 has a narrow, almost setiform medial subterminal appendage. *Diacyclops stygius* sensu stricto (Chappuis, 1924), another European species, has similarly narrow terminal appendages. In *D. stygius* the swimming legs are not much reduced, only the endopodites of legs 1 and 2 being biarticulate. When more information is available about these latter taxa it may become apparent that they form a monophyletic group with *D. virginianus*.

The slender terminal appendages and proximal fusion of the fifth leg of *D. virginianus* together constitute a situation intermediate between the usual structure of the fifth leg in *Diacyclops* and some genera with a more reduced structure, particularly the European *Graeteriella* and *Speocyclops*, composed of subterranean species. In *Graeteriella* the proximal article together with its seta is usually completely lacking, but the seta may rarely occur inserted lateral to the base of the remaining (distal) article (Lescher-Moutoué 1968). The terminal appendages of leg 5 in *Graeteriella* are setiform. In *Speocyclops* the leg 5 articles are fused, and the three appendages are also setiform in most cases.

The genus *Diacyclops* as now composed includes some 77 species and many additional subspecies. It is the most successful and diverse of the cyclopid genera, with species living in all known types of continental epigean and hypogean habitats. Most of the hypogean species have been described from Europe where studies of subterranean habitats are well advanced. Because of this bias in available information, it is not surprising that some of the known species that are most similar to *D. virginianus* are European.

The variety of body forms and modifications of appendages contained within the genus has led to difficulties in adequate definition. The most recent reformulation of the genus concept by Monchenko (1985) consisted of a return to the structure of leg 5 as the fundamental unifying generic feature, while accepting a broad range of variation in other structures. The discovery of *D. virginianus* further confuses the issue of definition while demonstrating a close relationship between some of the more reduced interstitial members of the genus and other subterranean genera.

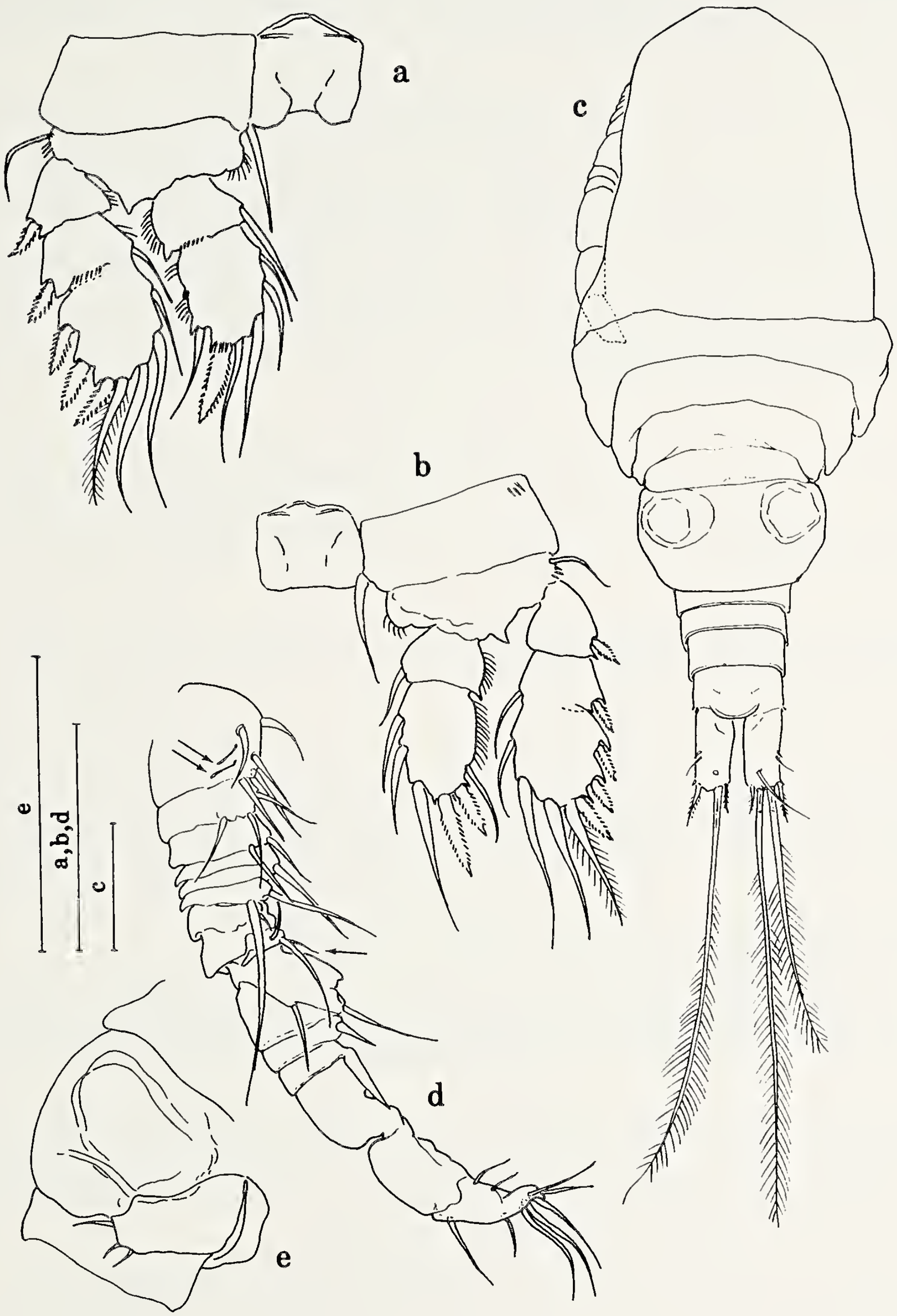

Figure 3. *Diacyclops virginianus*, new species: a, b, Female holotype, USNM 259513; c-e, Male allotype, USNM 259514: a, Leg 3 and coupler, anterior; b, Leg 4 and coupler, posterior; c, Habitus (anterior part of body slightly compressed); d, Antennule; e, Anterior urosome, right lateral. Figure 3a, b drawn at 1000 X from dissected and mounted specimen in PVL; Figure 3c, e drawn at 600 X in glycerine; Figure 3d drawn at 1000 X in glycerine; all scales indicate 50 µm.

As additional species are discovered on continents outside Europe we can expect that understanding of systematic and biogeographical relationships within the Cyclopidae will be improved beyond its present fragmentary state.

Acknowledgments

The Sisters of Notre Dame Academy and Mr. and Mrs. Ridgley White kindly permitted access to the study site on Goose Creek. Special appreciation is due all those who patiently sorted tiny copepods from the sediment samples: Peter Arensburger, Christine Hakenkamp, Monica Jankowski, Timothy Manuelides, Andy Martin, Margaret Palmer, Misty Saunders, and Marcia Shofner. The collections were supported by National Science Foundation Grant No. DEB 9106781 to Dr. Margaret A. Palmer.

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Disjunct Populations of Northern United States Butterflies in Garrett County, Maryland

Richard H. Smith, Jr.

Twenty thousand years ago, when the Laurentide ice sheet extended south as far as central Pennsylvania, western Maryland and adjacent parts of the Appalachian Mountains were vegetated by flora typical of boreal tundra (Pielou 1991). At that time many northern species were pushed south into our region. As the glacier receded and conditions warmed, those northern species again moved north to eventually assume the ranges that they occupy today. As those range adjustments occurred, occasional isolated populations were left behind as relicts where local conditions remained suitable, generally at higher elevations where cooler conditions prevailed. Garrett County, which rests entirely within the Appalachian Plateau, well above the average elevation of the rest of Maryland, contains several sites where these typically more northern species occur (Fenwick and Boone 1984, Lee 1976). Among the butterflies, there are three species that fit this pattern, occurring in Garrett County in a few isolated colonies separated by a significant distance from the main species range to the north. These species are the bog copper, represented by the nominate subspecies *Lycaena epixanthe epixanthe* (Boisduval and Leconte); Harris' checkerspot, represented by the southernmost subspecies *Chlosyne harrisii liggetti* (Avinoff); and the Atlantis fritillary represented by the nominate subspecies *Speyeria atlantis atlantis* (Edwards).

The bog copper is restricted to acid bogs which support the recorded larval host plants, the large and small cranberry (*Vaccinium macrocarpon* Ait. and *Vaccinium oxycoccos* L.) (Fenwick and Boone 1984, Wright 1983). The bog copper was first discovered in Maryland in 1981 (P. J. Kean and W. A. Andersen in Simmons et al. 1981 [1983]). It is found in only a few Garrett County bogs including the Cherry Creek Glades near Bittinger and the Cranesville Swamp on Maryland's western border (Wright 1982). Both of these bogs support sizable (several acre) concentrations of cranberry growth. These relict colonies of this subspecies are well over 150 miles south of the nearest population in Erie County, Pennsylvania (Genoways and Brenner 1985). Large areas of cranberry bog habitat also occur southwest of Garrett County in the so-called Cranberry Glades district of West Virginia. However, repeated efforts have failed to reveal additional colonies of *L. epixanthe* there (Wright 1993 and personal communication), demonstrating that the local distribution of this species is quite restricted in this corner of its range .

Lycaena epixanthe produces a single brood each year with the adult flight period in mid-July. Its life cycle is inextricably tied to the seasonal cycle of the cranberry plant (Wright 1983). Eggs are deposited singly on the undersurface of cranberry leaves where they remain dormant, and often submerged, until they hatch the following spring. Larvae feed on cranberry shoots and leaves, and pupate under the leaves. Adult emergence corresponds with the cranberry bloom and they nectar exclusively on these blossoms.

Harris' checkerspot, discovered in Maryland in 1985 (R. H. Smith in Winter 1987), is another northern species that is found in Garrett County in only a few secluded weedy bogs that support generous growths of its sole larval host plant, flat-topped white aster (*Aster umbellatus*

Mill.). This aster, also a northern species, usually occurs in low-lying areas at higher elevations where the "frost pocket effect" maintains a more northern microclimate (Fenwick and Boone 1984, Lee 1976). These habitats are also characterized by floating mats of *Sphagnum* moss and tree-lined borders consisting of red spruce (*Picea rubens* Sarg.), white pine (*Pinus strobus* L.) and hemlock (*Tsuga canadensis* [L.]). Since the contiguous range boundary of *C. harrisii* extends south only to central Pennsylvania (Genoways and Brenner 1985), the Garrett County, Maryland occurrence, along with occurrences in four nearby, higher elevation West Virginia Counties (Pendleton, Pocahontas, Randolph, and Tucker) (Allen 1987), represents a disjunct southern population. No occurrences of this butterfly have been reported further south in recent years (Opler and Malikul 1992).

In Maryland the Harris' checkerspot flies during mid-June. Third and fourth instar larvae overwinter at the base of the foodplant (Scott 1986) and final growth and pupation occur the following spring. Adults are frequently observed sipping moisture at wet areas along dirt roads or nectaring at ox-eye daisies (*Chrysanthemum leucanthemum* L.), often hundreds of yards from the bogs in which they matured.

The Atlantis fritillary was reported from Garrett County, Maryland as early as 1940 (F. H. Chermock in Simmons 1963), but few additional records were obtained until the mid-1980's (A. P. Platt in Winter 1986, and R. L. Waldrep in Winter 1987). These later records demonstrate that a small but viable colony of this species occurs in and around the Cranesville Swamp. It also occurs in ten contiguous counties of West Virginia, roughly encompassing a high elevation area west and south of Garrett County, including most of West Virginia's Monongahela National Forest (Allen 1987). No recent records exist in the eastern United States south of this area. To the north there is a notable break between the Garrett County-West Virginia occurrences and the nearest population in central Pennsylvania, but beyond there the distribution of this species is continuous north into Canada (Opler and Malikul 1992).

The Atlantis fritillary has a single annual brood and adults fly in Maryland from mid-June to early July. Larvae utilize various violets as host plants (e.g., northern blue violet, *Viola septentrionalis* Greene) (Scott 1986). The butterfly is found along woods roads and other openings in forests, usually near boggy areas.

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NATURAL HISTORY SOCIETY OF MARYLAND, INC.
2643 North Charles Street
Baltimore, Maryland 21218

The Maryland Naturalist

THE NATURAL HISTORY SOCIETY OF MARYLAND

Volume 37, Number 3-4 July/Dec. 1993

ISSN 0096-4158

The Maryland Naturalist

Volume 37, Number 3-4 July/Dec. 1993

Contents

Arnold W. Norden, Editor

Mailing Date: 6 February 1994

Cover Illustration: Male ruby-throated hummingbird (*Archílochus cólubris* [L.]) feeding at flower of trumpet creeper (*Campsis radicans* [L.]). From an original drawing by Ryan L. Chapin, an art student at the University of Maryland, College Park. Provided by Gerald Einem.

Notes on the Occurrence of the Freshwater Jellyfish, *Craspedacusta sowerbyi* Lankester, in Baltimore County, Maryland

Kenneth C. Bagley

Craspedacusta sowerbyi is placed in the class Hydrozoa of the Phylum Coelenterata. Although commonly called the freshwater jellyfish, it is not one of the "true jellyfishes" which belong to the class Scyphozoa.

Reproduction in *C. sowerbyi*, as in most coelenterates, involves alternation of generations between a small (0.1 to 0.2 mm) non-tentacled, stationary colonial polyp and a larger (12 to 22 mm) mobile medusa. Asexual reproduction in the polyp stage takes place by simple budding. Budding can produce either new polyps or medusae. Typically, all of the medusae in a given area are the same sex, presumably as a result of asexual propagation by polyps (Hyman 1940). Upon detaching from the mother polyp, the medusae are less than 1 mm in diameter and have only eight tentacles. The size of the medusa and the number of tentacles increases rapidly, ultimately reaching a diameter of 12 to 22 mm with up to 600 tentacles (Grizimek 1984). Reproduction by medusae is sexual, with the sperm and eggs being released into the water. The resulting zygotes form new polyps.

Craspedacusta sowerbyi was discovered in a London botanical garden, in a pond with Amazon water lilies. Some investigators feel that the animals were brought from Brazil with the plants (Hyman 1940). Since 1908, when it was first noticed in the United States, it has been found in nearly all states east of the Mississippi River, and several western states. The first record from Maryland was provided by Allan (1952), who recorded it from the Potomac River at Plummers Island. Rivers (1987) subsequently reported this species from ponds in Montgomery and Washington Counties. Grogan (1989) reported another sighting in a pond in Dorchester County, and Turek (1992) reported it from a lake in Anne Arundel County. These five records represent the only published reports of freshwater jellyfish from Maryland. This note reports an additional Maryland record, the first from Baltimore County.

On 20 August 1993, I found medusae of *C. sowerbyi* in the Beaver Dam marble quarry in Cockeysville, Baltimore County, Maryland. The quarry, located about fifteen miles (24 km) north of Baltimore City, was active in the late 1800's and early 1900's. It was abandoned in the 1930's and subsequently flooded by springs. Since then the quarry has been home to the Beaver Dam Swim Club. It has about four surface acres (1.6 hectares) and an average depth of 50 feet (15 meters). I observed the medusae at the north west side of the quarry about 2 feet (61 cm) below the surface, near the face of a submerged cliff. Two specimens were collected and survived for two days under refrigeration.

I returned to the quarry on 1 September 1993 around 1:00 PM. At that time I observed thousands of medusae, most of which were congregated in the same area where they had been observed previously. The cliff face at that location supports a thick growth of aquatic algae. I assume that the thickly vegetated rock face is the home of the *C. sowerbyi* polyps.

On 3 September, medusae were still abundant and 27 specimens were collected and returned to Essex Community College where they were placed in an aquarium. The aquarium,

filled with half tap water and half water from other aquaria in the lab, also received clumps of algae and associated fauna from the quarry. The chemistry of the aquarium water was found to be nearly identical to the quarry water. Water chemistry measurements made at the quarry on 3 September are given below. Levels of ammonia nitrogen, sulfide, phosphates, chromate and iron were too low to be measured with my equipment.

Temperature	80.6 °F (27 °C)
pH	7.8
Dissolved oxygen	10 ppm
Carbon dioxide	6 ppm
Nitrate	0.5 ppm

None of the captive specimens lived longer than four days. By that time the aquarium had experienced an algal bloom and the water was bright green. Water chemistry measurements indicated that the pH had increased from 7.8 to 9.0, and nitrates had increased from 0.5 to 2.0 ppm. All other measurements remained the same.

It is generally believed that the appearance of medusae of *C. sowerbyi* is sporadic and unpredictable. However, when I spoke with a life guard at the swim club he informed me that these jellyfish show up in the quarry each year at the end of August. I plan to investigate his claim in years to come.

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Ant-plant Mutualism: the Trumpet Creeper (*Campsis*) Ant-guard

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Introduction

The trumpet creepers are members of the genus *Campsis* of the family Bignoniaceae. Most of the Bignoniaceae are lianas, usually adapted in one way or another to climbing in humid forests where they abound. The family is mainly tropical, and primarily centered in South America; however, *Campsis radicans* (L.) Seem., one of a few temperate representatives, is a common woody vine of the eastern and midwestern United States.

Many species of Bignoniaceae have extrafloral nectaries, sugar secreting glands found away from the flower or on abaxial flower parts. The trumpet creepers, North American *C. radicans*, Old World *Campsis grandiflora* (Thumb.) K. Schumann, and the hybrid *Campsis* x *tagliabuana* (Xisi.) Rehder (*C. radicans* x *C. grandiflora*), have four distinct extrafloral nectary systems. The minute donut-shaped glands that constitute each system are located on petioles, calyxes, corollas, and fruits. The nectary systems vary with regard to the average number of glands, size of the nectaries, and kind and ratio of nectar sugars (Elias and Gelband 1975) and amino acids (Baker et al. 1978). Extrafloral nectar, as compared to floral nectar, is richer in amino acids and contains sucrose.

Extrafloral nectar is very attractive to ants, wasps and other insects which may protect *Campsis* from phytophagous insects. According to the observations of Elias and Gelband (1975), ants attracted to the nectaries may or may not protect the *Campsis* vine from nectar robbing or leaf, fruit or flower eating insects. In Illinois the large aggressive ant *Formica* sp. (*fusca* group) was an effective protector of *C. radicans*, preventing nectar robbing by bees. However, a smaller less aggressive ant, *Crematogaster lineolata*, was unable to prevent nectar robbing. Plants occupied by *C. lineolata* had a significant number of holes of the type made by nectar-robbing bees in their corollas, however, plants occupied by *Formica* lacked these holes (Elias and Gelband 1975). The phenomenon of ant guarding is not uncommon; both experimental data and an enormous body of correlative data suggest that many plant species that have extrafloral nectaries are protected from herbivore damage by ants and wasps visiting the nectaries and displaying aggressive or predatory behavior towards herbivores (Beattie 1985, Benson 1985, Huxley 1986, Huxley and Cutler 1991).

Moreover, ants attracted to nectaries can effectively reduce competition from plants of other species. *Azteca* ants, that obligatorily live in neotropical trees of the genus *Cecropia*, kill or remove the ends of vines that climb on the *Cecropia* trees. Presumably this aids the fast-growing *Cecropia* to maintain an emergent position in the forest canopy (Janzen 1969).

Besides extrafloral nectaries, *Campsis* species have ovarian nectaries deep within large orange trumpet-shaped flowers. The copious nectar produced by the ovary attracts ruby-throated hummingbirds (*Archílochus cólubris* [L.]) and bumblebees (*Bombus* sp.), the primary pollinators of North American *Campsis*.

This paper contains novel observations of ants and other insects associated with *Campsis* extrafloral nectaries, and provides further evidence in support of a mutualism between ants and *Campsis*. In this study, mutualism was supported by:

1. The presence of many species of aggressive and predatory ants, wasps and other insects attracted to *Campsis* extrafloral nectaries.

2. The presence of *Campsis* herbivores, some of which are seed predators or flower herbivores.

3. Observations that show that an absence of ants is correlated with increased herbivore damage to flowers and flower buds.

4. Ant behavior near extrafloral nectaries that results in the removal of foreign plant material from *Campsis*.

5. The presence of protein-building amino acids in extrafloral nectar that may enhance its nutritive value for ant larvae, and non-protein amino acids that may deter nectar robbing insects.

Methods

Ants and other insects feeding at *C. radicans* and *C.* x *tagliabuana* extrafloral nectaries were observed for evidence of protective behavior, collected and identified. Insect herbivores feeding on *Campsis* flowers, fruits or leaves were also collected and identified. Specimens from Delaware and Maryland were studied during the summers of 1977-1979, 1989, and 1991-1993. Most insects were identified by Research Entomologists at the Systematic Entomology Laboratory of the U.S. Department of Agriculture. The specimens are in the author's collection. Some moths and flies were reared from larvae.

For the purpose of describing the location of insects at nectaries, the calyx and corolla nectary systems are considered one location. In the past these nectary systems have been separated based upon their location and morphology. However, in this study insects feeding at these nectaries were grouped together because of the close proximity of the calyx and corolla, and their use by ants as a single foraging territory.

To determine the effectiveness of *Camponotus pennsylvanicus* as an ant-guard on the hybrid *Campsis* (Site II), 37 inflorescences were inspected on six days (September 1, 3, 5, 7, 13, and 16, 1992), continually from 1800-2400 hrs for a total of 36 hrs. The number of ant-free and ant-occupied inflorescences, herbivore damage to flowers or flower buds, and the presence of herbivores were documented during each of the six observation periods.

The speed, effectiveness and specificity of black carpenter ant (*C. pennsylvanicus*) workers in removing foreign leaf or tendril fragments, or *Campsis* leaf fragments placed on the hybrid *Campsis*, was compared. Leaf sections, 2 x 7 mm, were cut from fresh leaves of hedge bindweed (*Calystegia sepium* [L]. R. Br.), Virginia creeper (*Parthenocissus quinquefolia* [L.] Planch.) and

hybrid *Campsis*. The Virginia creeper tendril fragments were 10 mm in length. The leaf and tendril fragments were moistened with water to serve as an adhesive, and placed on the hybrid *Campsis* calyx (flower or flower bud) using forceps. One to five of these fragments were placed on an inflorescence for each trial. There were eleven trials using four inflorescences, each with two or three ants present at the time of observation.

Amino acid analysis of extrafloral nectar from the hybrid *Campsis* was done by ion exchange column chromatography using an automatic amino acid analyzer. The nectar was collected from hybrid *Campsis* calyx nectaries at Site II using a glass micropipet. Ninety-four microliters of nectar was analyzed.

Study/Collection Sites

SITE I.

This site was in the historic district of Ellicott City, Howard County, Maryland. A single small (1 meter) *Campsis radicans* was located near the edge of a parking lot where it meets a large residential lot. The edge of the residential lot had a number of large catalpa (*Catalpa speciosa* [Warder ex Barney] Englm.) trees.

SITE II.

This large trumpet creeper hybrid (*C.* x *tagliabuana*) was in a residential area of Columbia, Howard County, Maryland. The vine was growing on the side of a carport at the author's residence where it was planted sometime before 1974. It was 3.0 meters tall and had a maximum stem diameter of 7 cm. The area surrounding the vine had many large trees, shrubs and a fallen log. Nearby was a heavily wooded stream valley.

SITE III.

The Broadkill Beach, Sussex County, Delaware site was on the northern edge of the Prime Hook National Wildlife Refuge. Here an extensive wetland met a vegetated old dune along the south shore of Delaware Bay. A single *C. radicans* about 2.0 meters in height was in an area densely wooded with native trees and shrubs.

SITE IV.

This site was located at the U.S. Department of Agriculture, Beltsville Agricultural Research Center-West in Beltsville, Prince Georges County, Maryland. *Campsis radicans* vines were located along an old canal spoil bank. The area was open, without trees or shrubs except for a few very small ones. As a result, the trumpet creepers lay on the ground or on low vegetation. The spoil bank, bordered on the side away from the canal by a open field, had many *C. radicans* vines which were difficult to distinguish as individual plants due to the dense tangle of vines and herbaceous vegetation.

SITE V.

This site was at the Maryland Ornithological Society Irish Grove Sanctuary near Salisbury, Wicomico County, Maryland. A number of *C. radicans* were growing along the upland wooded edge of a brackish marsh.

Results and Discussion

Ants at Extrafloral Nectaries: Their Distribution and Interspecific Interaction

At the five study sites, 13 species of ants representing seven genera were observed feeding on *Campsis* extrafloral nectar (Table 1). Of these, nine species of ants were observed feeding at flower (calyx and corolla) or flower bud extrafloral nectaries, six species at fruit nectaries, and three species at petiole nectaries (Figures 1-5). Ants were never seen entering the corolla to feed on ovarian nectar or pollen.

The species of ants collected from a plant varied from one summer to another or even over a period of a few days. The ants collected from the Columbia, Maryland (Site II) plant were of different species composition each year that collections were made in 1977-1979, and 1989. Also, during a single summer, the ant species may change abruptly. In 1980, within two days the Columbia plant lost its ant-guard consisting of *Camponotus ferrugineus* at the calyx, corolla and fruit nectaries, and *Tetramorium caespitum* at the petiole nectaries. These dominant species were replaced by *Prenolepis imparis* (a species rarely seen at the nectaries) at all nectary sites. The change of species occurred just after passage of a cold front resulted in much lower temperatures. *Prenolepis imparis* is a species known for its activity in cold weather (Smith 1965), thus the change in the ant-guard may have been an example of "opportunistic" behavior of a low-ranking species as described by Wilson (1971). Despite instances of abrupt change in species, the usual species composition at a nectary system over one summer was quite stable.

Each nectary system (calyx/corolla, fruit, or petiole) may have a different species of ant. For example, on August 29, 1978 the Columbia plant had *Camponotus nearcticus* and *Formica subsericea* feeding at the calyx/corolla nectaries, *Tapinoma sessile* at the fruit nectaries, and *T. caespitum* at the petiole nectaries. Because of the affinity of the ants for a particular nectary system and the unique parameters of each system (location, average number and size of nectaries and ratio of amino acids and sugars), each nectary system exhibits the critical dimensions of a minor biotic niche (Hölldobler and Wilson 1990). Each of the four ant species appear to have better or unique adaptations to one or more parameters of the nectary system where they were feeding. Without competition from other ant species, however, a single species of ant may occupy all of the nectary systems on the plant.

Most of the 13 ant species were observed feeding at one or two nectary sites. Ten species of ants fed at one nectary site (five calyx/corolla, two fruit, and three petiole), three species fed at two sites (calyx/corolla and fruit) and one species fed at all three nectary sites. The species of ant present at a *Campsis* nectary system may depend upon the relative aggressiveness of opposing species. In support of this is the behavior of *C. nearcticus* and *F. subsericea* observed on the same inflorescence, feeding at calyx/corolla nectaries at Site II in 1978. When the two species met, *F. subsericea* would immediately attack *C. nearcticus* and the latter species would drop off the vine to the ground. This was observed repeatedly. A few days later, all of the *C. nearcticus* were restricted to a few inflorescences not occupied by *F. subsericea*. In this manner, the most aggressive ant species dominated nectaries of its choice, while evicting less aggressive competitors.

Table 1. Species of worker ants feeding at trumpet creeper extrafloral nectaries (calyx and corolla, fruit and/or petiole). The plants at all sites except Columbia are *C. radicans*. The Columbia specimen is a hybird *Campsis*. Petioles without ants present may not have been secreting nectar. (* Nectaries absent at time of observation.)

Date of Collection	Location	Ovary	Calyx and Corolla	Fruit	Petiole
6/17/76	Ellicott City, MD Site I	*	*	*	*Camponotus subbarbatus* Emery
9/3/77	Columbia, MD Site II	None	*Camponotus pennsylvanicus* (DeGeer) *Crematogaster cerasi* (Fitch) *Lasius neoniger* Emery	*	None
8/29/78	Columbia, MD Site II	None	*Camponotus nearcticus* Emery *Formica subsericea* Say	*Tapinoma sessile* (Say)	*Tetramorium caespitum* (Linné)
6/12/79	Broadkill Beach, DE Site III	None	*Crematogaster clara* (Mayr)	*	None
8/25/79	Columbia, MD Site II	None	*Camponotus ferrugineus* (Fabricius)	*	None
9/21/80	Columbia, MD Site II	None	*Camponotus ferrugineus* (Fabricius)	*Camponotus ferrugineus* (Fabricius)	*Tetramorium caespitum* (Linné)
9/23/80	Columbia, MD Site II	None	*Prenolepis imparis* (Say)	*Prenolepis imparis* (Say)	*Prenolepis imparis* (Say)
8/29/89	Columbia, MD Site II	None	*Camponotus pennsylvanicus* (DeGeer)	Present, not identified	None
8/9/91	Beltsville, MD Site IV	None	*Formica subsericea* Say *Crematogaster clara* Mayr *Formica pallidefulva nitidiventris* Emery	*Formica subsericea* Say *Crematogaster lineolata* (Say) *Formica pallidefulva nitidiventris* Emery	None

Figures 1-5. Insects at hybrid *Campsis* extrafloral nectaries. 1. *Camponotus pennsylvanicus* feeding at a corolla nectary (left) and a calyx nectary (right). 2. *Camponotus pennsylvanicus* feeding at a calyx nectary, showing a donut-shaped nectary (see arrow). 3. *Camponotus ferrugineus* feeding at flower bud (calyx) nectaries. 4. *Camponotus pennsylvanicus* patrolling a leaf-stalk near petiole nectaries (see arrows). 5. *Vespula* sp. and *C. pennsylvanicus* feeding at fruit nectaries.

The absence of ants on some petiole nectaries (Table 1) may be due to lack of nectar production, not the availability of ants. These nectaries were on older shoots that appeared to have ceased to need ant protection. In his review of the subject, Beattie (1985) proposed that extrafloral nectar production is limited to times when new meristems and leaves are chewable, palatable, and rich in nitrogen.

Most of the thirteen species of ants I collected at extrafloral nectaries are predatory. Smith (1965) in his review of the biology of house-infesting ants described the feeding habits of ten of the ant species identified in this study. Nine of these were reported to eat live insects.

Wasps, Bees, Flies and True-bugs at Nectaries: Their Interaction With Ants

Insects other than ants that were collected while feeding at *Campsis* extrafloral nectaries were five species of wasps (for example, see Figures 5 and 6), two species of bees, five species of flies and one true-bug (Table 2). The diversity of species other than ants attracted to flower extrafloral nectar may at times greatly exceed the number of ant species on a vine. For example, at Site II in 1977, nine species of insects other than ants were seen competing with three species of ants for the calyx/corolla extrafloral nectar resource. The ants almost always displayed a characteristic aggressive and agitated behavior, chasing the competitor insect away from the nectar source. When many wasps, bees, and flies were present, the ants spent a significant amount of time driving them away because of their number and habit of returning to the nectaries soon after being driven away. However, wasps, bees and flies were rarely observed driving away ants; in fact, the ants almost always aggressively defended the territory around their source of nectar.

Specific aggressive encounters in 1978 at Site II were the ant, *C. nearcticus*, driving away the bee, *Dialictus* sp., and the ant, *Formica subsericea*, driving away the large fly, *Oxysarcodexia* sp., and the hornet, *Vespula maculifrons*. Another hornet, *Vespula germanica*, was driven away from flower bud extrafloral nectaries by the ant, *Camponotus pennsylvanicus*. These same hornets then entered nearby flowers and attacked honey bees, *Apis mellifera*, gathering pollen at anthers. The bees were quickly driven away, preventing a further loss of pollen to an insect that is probably not an effective pollinator of *Campsis*.

Although wasps are frequently driven away from extrafloral nectaries by the attending ant-guard, they may still be effective agents in reducing damage by herbivores since many are predators or parasites of herbivores. Most adult wasps feed on floral or extrafloral nectar, and the plants to which they are attracted are often their principal hunting grounds (Evans and Eberhard 1970, Spradbery 1973). At night, however, wasps, bees and flies are rarely seen feeding at nectaries, yet the ants remain active as the sole deterrent to nocturnal insect herbivores and seed predators.

Bumblebees frequently visited *Campsis* floral (ovarian) nectaries, going from flower to flower in quest of nectar. A bumblebee feeding in this manner was collected at Beltsville (Site IV); it was identified as *Bombus pennsylvanicus* De Geer. At Columbia (Site II) a bumblebee visiting *Campsis* flowers pursued a female ruby-throated hummingbird which had been feeding

Table 2. Insects other than ants attracted to *Campsis* calyx/corolla extrafloral nectaries.

Date of Collection	Location	Species
9/3/77	Columbia, MD Site II	Hemiptera: Anthocoridae: *Orius insidiosus* (Say) Hymenoptera: Halictidae: *Dialictus zephyrus* (Smith) *Dialictus illinoensis* (Robertson) Vespidae: *Polistes fuscatus* (F.) *Vespula squamosa* (Drury) Eumenidae: *Stenodynerus* sp. Diptera: Muscidae: *Musca domestica* L. Sarcophagidae: *Sarcophaga* sp. Milichiidae: *Milichiella arcuata* (Lw.)
8/23/79	Columbia, MD Site II	Hymenoptera: Halictidae: *Dialictus* sp. Vespidae: *Vespula maculifrons* (Du Buysson) *Vespula germanica* (F.) Diptera: Sarcophagidae *Oxysarcodexia* sp.
8/9/91	Beltsville, MD Site IV	Diptera: Chloropidae: *Rhopalopterum umbrosum* (Loew)

at *Campsis* ovarian nectaries. The bumblebee flew after the hummingbird for 12 meters before returning to gather floral nectar again. The hummingbird did not return.

The dipterans attracted to calyx/corolla extrafloral nectaries (Table 2) are nectar robbers that do not benefit *Campsis* since they compete with the guarding ants and wasps for the nectar resource. The flies, *Sarcophaga* sp. and *Oxysarcodexia* sp., are in genera of saprophytic species. *Milichiella arcuata* and *Musca domestica* are also saprophytes. The frit fly, *Rhopalopterum umbrosum*, belongs to a family of flies that are either parasites on grasses, or saphrophytes.

A hemipteran, the pirate bug, *Orius insidiosus*, was also attracted to extrafloral nectaries. Although not abundant, they are predacious on mites, thrips, aphids and other small herbivorous insects which they may feed on while visiting the nectaries.

Herbivorous Insects That Feed on *Campsis*

Insects that fed on *Campsis* flowers, fruits or leaves were collected at Sites II and V. They were from the orders Dermaptera, one species; Orthoptera, three species; Lepidoptera, two species; Diptera, four species; and Hymenoptera, one species (Table 3).

A dermapteran herbivore, the European earwig, and three orthopteran herbivores, a katydid, a tree-cricket and a long-horned grasshopper were observed feeding on hybrid *Campsis* flowers or flower buds. These species are generalist herbivores. (See Table 3, and the next section of this report.)

The moth, *Clydonopteron sacculana*, a *Campsis radicans* seed predator specialist, was reared from *C. radicans* fruits collected on May 17 near Salisbury, Maryland (Site V). The dried fruits had over-wintered on the vine, and had not dehisced. Each fruit had one or more holes in the capsule wall which were plugged with silk and frass. *Clydonopteron sacculana* larvae with white bodies and dark heads infested each of the fruits. Eclosion of the moths began May 27.

Considerable information on the life history of this moth has been reported by Riley (1880) and Landis et al. (1992). The latter authors found that *C. sacculana*, a univoltine species, has two oviposition sites: green fruit and previously infested dry, over-wintered fruits. The eggs of larvae that feed on green developing fruit are deposited on the inside of the calyx. Although I did not observe oviposition, the location of the site inside of the calyx adjacent to the developing fruit suggests that the process could be impeded by the presence of aggressive ants feeding at nectaries on the outside of the calyx or corolla. Ants patrolling this area may repel moths attempting to oviposit, or remove eggs or hatching larvae before they enter the capsule to feed on the seeds.

Landis et al. (1993) also found the cocoons of the parasitoid wasp *Apanteles* sp. within empty *C. sacculana* larval cases. Their hypothesis, that the period from egg hatching to fruit entry is the most likely time for *Apanteles* oviposition in *C. sacculana* larvae, suggests that the wasp may feed at the nearby calyx or corolla extrafloral nectaries. Stephenson (1982) reported that the parasitoid *Apanteles congregatus* (Say) was a common visitor to the extrafloral nectaries on catalpa trees (*Catalpa speciosa*). This wasp is reported to lay its eggs on the catalpa sphinx

Table 3. Herbivorous insects and seed predators feeding on hybrid *Campsis* (Columbia, Maryland) or *C. radicans* (Salisbury, Maryland).

Date of Collection	Plant Location	Feeding Site and Species				
		Ovary	Anther (Pollen)	Corolla	Fruit	Leaves
5/15/79	Salisbury, MD Site V				Lepidoptera: Pyralidae: *Clydonopteron sacculana* (Bosc) Diptera: Chloropidae: *Conioscinella hinkleyi* (Mall.)	
8/27/89	Columbia, MD Site II		Hymenoptera: Apidae: *Apis mellifera* Lynn.			
8/19/90	Columbia, MD Site II					Lepidopteria: Sphingidae: *Paratraea plebeja* (F.)
9/16/92	Columbia, MD Site II		Dermaptera: Forficulidae: *Forficula auricularia* L. Orthoptera: Gryllidae: *Anaxipha exigua* (Say) *Oecanthus fultoni* Walker Tettigoniidae: *Montezumina modesta* (Br.v.W.)	Dermaptera: Forficulidae: *Forficula auricularia* L.		
5/20/93	Columbia, MD Site II		Diptera: Cecidomyiidae: *Contarinia tecomae* (Felt) adult			Diptera: Cecidomyiidae: *Contarinia tecomae* (Felt) larva
6/21/93	Columbia, MD Site II	Diptera: Cecidomyiidae: *Contarinia* sp. *Prodiplosis* sp.				

moth (*Ceratomia catalpae* [Boisduval]), the principal herbivore of *C. speciosa* (Baerg 1935). A parasitoid (*Apanteles*) should be looked for at *Campsis* extrafloral nectaries.

The larva of the plebeian sphinx moth (*Paratraea plebeja*) was observed feeding on the hybrid *Campsis* during five consecutive days in August. The larvae, 42 mm in length, was only seen feeding on *Campsis* leaves. Since the petiole nectaries were not secreting nectar and ants were not present in the areas where *P. plebeja* was foraging, interactions with ants were not observed. Predation by ants on eggs or early instar larvae should be looked for.

The dipteran, *Conioscinella hinkleyi*, was reared from the same dried fruits from which the moth, *C. sacculana*, was reared. The fly may be a seed predator or feed on frass; however, its interaction with the ant-guard, if any, is unknown.

Another dipteran, *Contarinia* sp., (an undescribed species, see Gagné 1989) was reared from hybrid *Campsis* flowers. These minute gall midges were active at night when swarms of 12 or fewer were seen within open corollas. Female *Contarinia* sp. were observed resting on anthers or on the corolla near the anthers, where they fed on pollen. Also at night, adults were frequently observed on flower buds. The larvae of this species were discovered feeding near the base of the ovary where they were readily seen moving about in the ovarian nectar. Larvae were also found in aborted flowers and flower buds that dropped to the ground. It has not been determined if the larvae are responsible for the failure of fruit to set. Although interaction of *Contarinia* sp. with guarding ants was not observed, ants feeding at calyx (flower bud) or flower extrafloral nectaries could interfere with oviposition, or prey on eggs or larvae.

Another gall midge of the same genus, *Contarinia tecomae*, rolls the edges of *Campsis* leaflets. *Campsis radicans* is its only previously known host (Gagné 1989). At Site II, *C. tecomae* infested hybrid *Campsis* leaves were common. The rolled leaflets were usually shaded from above by uninfested leaves, and were on shorter stems than uninfested leaves. On June 2, 1993, five *C. tecomae* infested leaflets were removed from the large hybrid *Campsis* and each leaflet was placed in a separate compartment of a clear plastic pillbox with wet cotton wrapped around the end of the broken petiole. Most of the mature larvae or pupae were in transparent silk cocoons which remained attached within the rolled leaflet edge. Eclosion began on June 3, 1993 and ended June 5, 1993, producing nine adult midges. The number of adult *C. tecomae* ranged from one to four per leaflet. Ants feeding at petiole nectaries foraged on infested leaflets and may feed on *C. tecomae* eggs or larvae, however, the rolled leaf edge and the cocoon may deter predation by ants. Eggs or early instar larvae may be more vulnerable to predation.

A larva of a third species of gall midge, *Prodiplosis* sp., was also found infesting hybrid *Campsis* flowers. The flowers were collected on June 21, 1993. On July 1, 1993 an adult male *Prodiplosis* sp., and a number of *Contarinia* sp. emerged from the same flowers. In addition, two adult female *Prodiplosis* sp. were collected from flower buds at night on July 9, 1993. These midges may have been feeding at calyx nectaries or ovipositing on the buds.

Campsis is unique in having four distinct extrafloral nectary systems (Elias and Gelband 1975), separated from one another in time (developmental stage) or location. This suggests that *Campsis* may have evolved nectary systems in response to a number of different herbivores, each

of which specialized, ovipositing or feeding on a particular plant organ which developed a strategically located nectary system. These investigations show that there are *Campsis* herbivores that restrict feeding to particular plant parts (calyx/corolla, leaves or fruit), each of which has a nectary system which attracts aggressive or predatory ants.

Herbivore Damage:
Differences Between Ant-free and Ant-occupied Inflorescences

Observation of 37 inflorescences on a hybrid *Campsis* vine (Site II) showed that *Camponotus pennsylvanicus* occupied inflorescences were free of herbivores and new herbivore damage during 36 hrs. of observation. However, ant-free inflorescences incurred 11 instances of herbivore damage and were occupied by five species of dermopteran and orthopteran herbivores during this same period.

A six hour observation period, from 1800h-2400h, was selected because preliminary studies showed that most herbivore damage to inflorescences occurred at night, and that the herbivores were nocturnal insects. During the six observation periods, ant-occupied inflorescences had either two or three black carpenter ants, *C. pennsylvanicus*, the only species of ant on the vine.

This section reviews observations made during the six hour observation period on each of the six days. During the first observation period, September 1, 1992, two of three ant-free inflorescences were damaged by herbivores. One inflorescence had a 4 mm deep cavity on the side of a flower bud, and another flower with a 5 x 30 mm hole in the corolla and a 4 mm diameter opening in the calyx. A second ant-free inflorescence had a flower bud with a 4.5 mm deep cavity on one side. Crickets and an earwig were seen on both damaged inflorescences but were not collected or identified. None of the 34 ant-occupied inflorescences had herbivore damage, nor were herbivores present.

During the second observation period, September 3, five of the inflorescences were ant-free. Three of these were occupied by the earwig, *Forficula auricularia*. One of the earwigs was seen eating (at 2100h) the tip of an unopened corolla and the other two were setting beneath flower buds. Neither of the other two ant-free inflorescences were herbivore-occupied or had herbivore damage. None of the 32 ant-occupied inflorescences had herbivore damage, nor were herbivores present.

During the third observation period, September 5, five inflorescences were ant-free. On one of these an earwig, *F. auricularia*, was seen eating (at 2330h) a hole along the edge of an expanded corolla. On another ant-free corolla a tree-cricket, *Oecanthus fultoni*, was on an undamaged flower bud. None of the other inflorescences were herbivore-occupied or showed new herbivore damage.

During the fourth day of observation, September 7, six of the inflorescences were ant-free. On one of these inflorescences the tree-cricket, *O. fultoni*, was feeding on pollen at an anther, and at a second ant-free inflorescence an earwig, *F. auricularia*, was on a flower bud stem. None of the other 35 inflorescences were herbivore-occupied or had new herbivore damage.

On the fifth day of observation, September 13, ten inflorescences were ant-free. Three of these had an earwig, *F. auricularia*, inside of a corolla and two other ant-free inflorescences were occupied by tree-crickets, *O. fultoni*, which were on the outside of wilted corollas. On another ant-free inflorescence an unidentified katydid was seen eating an elongated hole in a newly opened corolla. None of the other 31 inflorescences were herbivore-occupied or had new herbivore damage.

During the sixth observation period, September 16, all of the inflorescences were ant-free. (All but five inflorescences had lost their flowers and flower buds due to cold, wet weather at the end of the flowering season.) At 2030h one of the flowering inflorescences was occupied by an earwig, *F. auricularia*, and a long-horned grasshopper, *Montezumia modesta*, both of which were feeding on pollen at anthers. On another inflorescence a tree-cricket, *O. fultoni*, had completely eaten both anthers and a part of the filaments. Also on this inflorescence was the bush-cricket, *Anaxipha exigua*; however, herbivore damage from this species was not observed. At other times this cricket was seen feeding on pollen (Figure 7).

This vine did not produce fruit during 1992, following a year of abundant fruiting during a record hot dry summer in 1991. It was not possible, therefore, to assess the effect of these herbivores on fruit or seed development.

None of the orthopteran and dermapteran herbivores observed during the six observation periods, or at other times, were seen feeding on *Campsis* leaves; in fact, they appeared to make a deliberate effort to reach the flowers or flower buds. This behavior may result from the presence of toxic substances in *Campsis* leaves that are lacking in non-photosynthetic flower parts, or the attraction may be the nutrient rich pollen.

Ants (*C. pennsylvanicus*) guarding an inflorescence were seen chasing tree crickets, which retreated, abandoning the inflorescence. Since most of the orthopteran herbivores seen have been adults or late instar nymphs, it would appear that pugnacious behavior, not predation, is the usual mode of protection by ants against large orthopteran herbivores.

Since the presence of herbivores and herbivore damage was restricted entirely to ant-free inflorescences (flower buds, corollas and stamens), these observations suggest that *C. pennsylvanicus* feeding at the calyx/corolla nectary system may increase the reproductive fitness of *Campsis* by protecting floral parts from phytophagous insects.

Removal of Leaf and Tendril Fragments by Ants

Black carpenter ant (*Camponotus pennsylvanicus*) workers, feeding at inflorescence extrafloral nectaries on *Campsis x tagliabuana*, removed foreign plant material, fragments of vine leaves and tendrils placed on flower calyxes and flower buds. These ants seldom removed similarly placed *Campsis* leaf fragments (Table 4).

During ten trials on August 6, 13, 15, 16, 17 and 19 using bindweed leaf fragments placed on calyxes, eight of ten leaf fragments were observed as ants grasped the fragments with their mandibles and dropped them to the ground. Seven of these were timed observations where the

Table 4. Behavior of black carpenter ants (*C. pennsylvanicus*) feeding at hybrid *Campsis* calyx and corolla nectaries. Ants were presented with fragments of leaves or tendrils from bindweed or Virginia creeper, or fragments of hybrid *Campsis* leaves which were taken from the plant on which the ants were feeding at Site II in Columbia, Maryland.

Date 1989	Time Observation Began	Number of Ants on Inflorescence	Leaf Fragment(s) or Tendril Placed on Inflorescence: Trumper Creeper		Bindweed		Virginia Creeper	
			No.	Condition	No.	Condition	No.	Condition
August 6	1700	2	0		1	Removed*	0	
August 12	1500	3	0		1	Removed 3 times* +	1	Removed * +
August 13	1200	3	3	Present after 45 min.	1	Removed in 5 min.*	0	
	1500	3	3	Present after 60 min.	1	Removed in 3 min.*	0	
	1600	3	4	Present after 60 min.	1	Absent within 60 min.	0	
August 15	1740	2	1	Present after 30 min.	1	Removed in 5 min.*	1	Removed in 5 min.*
	1807	2	1	Present after 13 min.	1	Removed in 3 min.*	1	Removed in 3 min.*
	1822	3	1	Present after 18 hrs.	1	Absent within 33 min.	1	Absent within 8 hrs.
August 16	1740	2	1	Present after 110 min.	1	Removed in 1 min.*	1	Present within 110 min.
August 17	1740	3	2	One removed in 20 min., One attempted removal after 25 min.	1	Removed in 23 min.*	1	Removed in 7 min.*
August 19	1323	2	2	One grasped but not removed after 31 min.	1	Removed in 24 min.*	1	Removed in 22 min.*

* Observed the ant remove the leaf fragment or tendril and drop it to the ground.
+ Tendril

Figures 6-9. 6. *Vespula* sp. feeding at flower bud (calyx) nectary. 7. The cricket, *Anaxipha exigua*, at anther, feeding on pollen within a *Campsis* flower (photographed after dark at an ant-free inflorescence). 8. *Camponotus pennsylvanicus* examining the edge of hybrid *Campsis* leaf fragment placed on a *Campsis* flower bud. 9. *Camponotus pennsylvanicus* (right) with a leaf fragment (see arrow) in its mandibles, dropping it free of the plant, with a second ant (left) looking on.

average time between the placement of the bindweed leaf fragment on the inflorescence and the time it was removed was 9.1 min. (range 3-24 minutes). During two trials when ants were not seen removing the bindweed fragments, two fragments were gone, one within 33 min. and the other within 60 min. after they were placed on the inflorescence. During three trials with a bindweed tendril placed on a calyx, *C. pennsylvanicus* quickly removed it each time.

Six trials with Virginia creeper leaf fragments placed on *Campsis* calyxes on August 15, 16, 17 and 19 resulted in removal by *C. pennsylvanicus* of four of six leaf fragments during a 22 min. period of continuous observation. The ants located the fragments and dropped them to the ground within an average of 9.5 min. (range 5-22 min). Another fragment was gone in less than 8 hours, and one was not removed after 1 hr and 50 min. A single trial with a Virginia creeper vine tendril, placed on a calyx, resulted in its prompt removal.

To determine if *C. pennsylvanicus* would remove hybrid *Campsis* leaf fragments as they remove bindweed and Virginia creeper fragments, during nine trials (August 13, 15, 16, 17 and 19) leaf fragments from each of the three plant species were placed near one another on adjacent *Campsis* calyxes on flower buds. Of 18 hybrid *Campsis* leaf fragments placed in this manner, only one was removed; the other 17 *Campsis* leaf fragments were still in place after 22 min. or more of continuous observation. By comparison, of the nine bindweed and six Virginia creeper leaf fragments placed on adjacent calyxes at the same time, 11 were observed as they were removed by ants, and three of the others were gone within eight hours or less. Fifteen of the *Campsis* leaf fragments were discovered by patrolling ants but the fragments were not taken in the ant's mandibles, except two fragments that were grasped but not removed. This experiment clearly demonstrated the ability of *C. pennsylvanicus* to distinguish foreign plant material from *Campsis* leaf fragments.

Removal of foreign plant material by *C. pennsylvanicus* from hybrid *Campsis* fruit was also documented. On August 14, 1991 a bindweed leaf fragment was placed on each of three fruits where ants were feeding at nectaries. After discovering a leaf fragment the ants moved rapidly over the fruit and then clustered around the leaf fragment, occasionally touching the edge of the fragment with their antennae. Two of the leaf fragments were removed and dropped to the ground by pairs of ants. The third leaf fragment was removed from the fruit by a single ant that carried it over one meter up the stem before it went out of view into foliage. All of the leaf fragments were removed from the fruit in the less than one minute.

The following account of the removal of a bindweed leaf fragment by *C. pennsylvanicus* will serve as an example of the leaf or tendril removal procedure. On August 6, 1989 at 1700h, two ants were patrolling an inflorescence. Both ants moved slowly, feeding at flower bud nectaries and generally patrolling the inflorescence until they were disturbed by the placement of a leaf fragment on a nearby flower bud. With this stimulus both ants ran rapidly over the inflorescence in an apparent random search for the source of the disturbance. Both ants periodically wagged their gasters in a vertical plane. First, the larger of the two ants discovered the bindweed fragment and examined it along the edge with its antennae (Figure 8) but did not move it. Then the second smaller ant grasped the fragment in its mandibles, carried it along the flower stalk for 10 cm and dropped it to the ground. This ant, as others (N=16), positioned itself on the inflorescence so that leaf or tendril fragment fell to the ground without striking the vine (Figure 9).

There were a number of variations on the procedure for removing leaf fragments. At times an ant repeatedly examined a leaf fragment before it was removed. On August 13 an ant examined a bindweed leaf fragment with its antennae five times before the fragment was removed from the vine. Between each examination, the ant patrolled a number of nearby flower buds and visited nectaries before returning to the leaf fragment. Another variation was the cooperative action of two or three ants working together to lift and carry a leaf fragment to a location where it could be dropped freely to the ground.

Camponotus pennsylvanicus workers were observed removing foreign leaf fragments in 1-24 min. (Table 4); however, under certain conditions ants would immediately remove leaf fragments placed nearby. This behavior appeared to result from a visual cue from a moving object placed near an ant. In this study, however, the leaf and tendril fragments were placed away from the ants, but in their foraging territory. Since the ants did not see the fragments move but rather discovered them after they were placed on the plant, the response of *C. pennsylvanicus* to leaf fragments must be due to visual, chemical or tactile stimuli other than those that elicit the aggressive behavior seen when an ant is presented with a moving object.

Other ant species varied in their response to foreign plant material. *Camponotus ferrugineus* feeding at hybrid *Campsis* extrafloral nectaries (Site II) repeatedly ignored bindweed leaf fragments placed in their foraging territory while *C. pennsylvanicus* on nearby inflorescences promptly removed them after they were discovered. Conversely, *Crematogaster clara*, feeding at *C. radicans* extrafloral nectaries at Beltsville (Site IV) removed crown vetch (*Coronilla varia* L.) leaf fragments taken from a plant which was growing nearby. The fragments were removed by *C. clara* in a manner similar to that employed by *C. pennsylvanicus*, with the ant dropping the fragment to the ground after carefully positioning itself so the fragment fell free of any obstruction.

To determine if *C. pennsylvanicus* workers would remove foreign leaf fragments located away from their foraging territory around nectar secreting extrafloral nectaries, leaf fragments from bindweed were placed on the main woody stem of the hybrid *Campsis* vine. On August 19, 1989 between 1630h and 1730h, a trail of 51 ants passed a row of seven bindweed leaf fragments placed across the stem. The ants, moving up and down the stem, hesitated or went around the leaf fragments but never removed any of the leaf fragments during one hour of observation. Similarly, when worker ants on trails away from the vine were presented bindweed fragments, they did not remove the fragments from the trail. This suggests that the behavior of *C. pennsylvanicus*, removing foreign plant material from *Campsis*, is restricted to areas around extrafloral nectary systems.

The behavior of *C. pennsylvanicus*, removing extraneous living material, is not restricted to *Campsis*. I observed *C. pennsylvanicus* remove bindweed leaf fragments placed on amaranth (*Amaranthus* sp.) in the same way they removed leaf fragments from *Campsis*. (The leaf fragments were placed near aphids where the ants were feeding on honeydew.) This pattern of behavior may also include the removal of "unwanted" insects. Eisner et al. (1978) reported that *C. pennsylvanicus* guarding wooly alder aphids (*Prociphilus tesselatus* [Fitch]) would remove green lacewing larvae (*Chrysopa slossonae* Banks) that had been artificially denuded of their waxy "wool" camouflage. Like the leaf fragments, the denuded larvae were grasped in the ant's mandibles and then positioned so they would drop freely to the ground. This behavior, the same

regimen seen when leaf or tendril fragments were removed in other contexts, illustrates the "principal of economy" in the evolution of ants. This concept holds that a characteristic of ant behavior is the repeated use of the same response or communication signal in different situations to achieve different purposes (Hölldobler and Wilson 1990).

The removal of foreign plant material, particularly vine leaves and tendrils, indicates that *C. pennsylvanicus* may engage in a more general cleaning or pruning behavior, removing competing plants from *Campsis*. Bindweed, Virginia creeper, and *Campsis* are all abundant in well-lit habitats where they may compete for light and nutrients. Heavily shaded parts of *Campsis* vines do not produce fruit, while areas of a plant in full sun may have abundant fruit production. Removal of foreign plant material by *Camponotus pennsylvanicus* may increase *Campsis* reproductive fitness by preventing shading.

Protection against plant competitors by ants has been described in tropical areas around the world. Janzen (1972) reported that the *Pachysima* ant on *Barteria* in a Nigerian rainforest chews invading vegetation and clears leaves of debris. In the neotropics, *Azteca* ants kill and remove vine ends that touch the trunks of *Cecropia* trees (Janzen 1969). Ants of the genus *Pseudomyrmex*, obligate mutualists on swollen-thorn acacias, also have plant-chewing habits which seems to be an extension of the general aggression toward any foreign object (Janzen 1967). In West Malaysia, myrmecophytic *Macaranga* tree species are occupied by the ant *Crematogaster borneensis* André, which prunes foreign plants. Ant-occupied *Macaranga* trees have a significantly lower degree of vine growth when compared to plants without ants (Fiala et al. 1989).

Despite the foreign plant cleaning behavior of *C. pennsylvanicus* described here, there is a lack of evidence of the biting or chewing behavior described for other species of ants. The extent to which *C. pennsylvanicus* foreign plant removal behavior is able to enhance the reproductive fitness of *Campsis* must still be determined.

Campsis Nectar Composition: New Calyx Amino Acids

An amino acid analysis of hybrid *Campsis* calyx nectar identified 20 protein-building amino acids, three of which have not been identified in previous reports. Baker et al. (1978) identified 18 protein-building amino acids from hybrid *Campsis* using paper chromatography. In my studies, using a more sensitive automatic amino acid analyzer, relatively small amounts of L-aspargine, L-aspartic acid and L-cystathionine (not cysteine as reported by Baker) were found, along with the other 17 usual protein-building amino acid complements. Besides, six nonprotein amino acids, ß-alanine, γ-amino butyric acid, ornithine and three unknowns were found to be present in calyx nectar.

In a comparison of floral and extrafloral nectar from many plant species, including hybrid *Campsis*, Baker et al. (1978) found that extrafloral nectar always differed in its complement of amino acids from that of floral nectar. Certain acids, most notably those of the cysteine group (including cystathionine found in this study), are more frequently represented in extrafloral nectars. These sulfur containing amino acids are required for normal insect development, especially the formation of the pupae (Trager 1953). Differences between extrafloral and floral

amino acid composition may relate to the use of the former in the nutritional needs of ant-guards and wasp-guards, and the latter in the nutrition of pollinators. Nonprotein amino acids, a greater variety of which are usually found in extrafloral nectar than floral nectar, may be toxic to extrafloral nectar robbers, insects that take nectar but are not a part of the ant-guard or wasp-guard (Baker et al. 1978).

Conclusion

Although much of this study is suggestive or correlative in its support of mutualism, it does provide an extensive amount of information that can serve as a basis for further study of the many fascinating components of the *Campsis*-ant-herbivore interaction. Certainly, controlled experiments with ant-free plants to assess fruit or seed production are needed. Also, our understanding of the exact means by which guarding hymenopterans benefit *Campsis,* and plant extrafloral nectar benefits nectar-feeding insects, is still far from complete. This investigation and the studies of Elias and Gelband (1975) provide a strong beginning to the elucidation of the nature of the *Campsis*-ant-guard mutualism.

Acknowledgments

My thanks to the following Research Entomologists at the Systematic Entomology Laboratory of the U.S. Department of Agriculture, Agricultural Research Service for insect identification: D.C. Ferguson (Lepidoptera), R.J. Gagné (Diptera), J.L. Herring (Hemiptera), V.T. Logan (Hymenoptera, bees), A.S. Menke (Hymenoptera, wasps) D. Nickle (Orthoptera), C.W. Sabrosky (Diptera), and D.R. Smith (Formicidae). Also my thanks to G.C. Eickwort, Department of Entomology, Cornell University for identifications (Hymenoptera, *Dialictus*) and E.D. Cashatt, Curator of Zoology, Illinois State Museum for discussions of *Clydonopteron* oviposition. The amino acid analysis was done by S. Pierce, Department of Zoology, University of Maryland, College Park.

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A New Site for the Swamp Pink (*Helonias bullata*) in Maryland

William S. Sipple

In the summer of 1989, Gene Cooley gave me some published extracts (Fessenden 1954, 1955) from the journal of Dr. Charles C. Plitt, a turn-of-the-century Baltimore botanist who spent considerable time studying the flora of Anne Arundel County. I was fascinated with Plitt's journal extracts and, since that date, have been trying to find some of the rare plants that he and his fellow "trampers" located in the "wilds of Anne Arundel County" in the late 1800's and early 1900's. I have had mixed success locating Plitt's sites, which I plan to report on in a subsequent more detailed paper. However, one outcome has been the discovery of the swamp pink, *Helonias bullata*, upstream from Lake Waterford in Anne Arundel County, Maryland. The purpose of this paper is to report on that find.

Since 1990, I have been searching for the swamp pink in both the Marley Creek drainage and the Magothy River tributaries above Lake Waterford, with no success. That is, until this spring when I walked the section of the stream between Route 10 and Lake Waterford. As I recorded it in my April 30, 1993 journal entry:

> "Well, I finally did it. I found one of the two main species I've been looking for, *Lygodium palmatum* (climbing fern) and *Helonias bullata* (swamp pink), about half way to Lake Waterford, on the left side of the floodplain going downstream. Plitt had reported both, somewhere between the Marley Station and Lake Waterford [see below]. Initially, the floodplain had a small (about 5' wide) stream with adjacent marshy openings in an otherwise forested swamp with numerous shrubs. Periodically, I noted non-flowering turks-cap lilies (*Lilium superbum*). Soon the stream was more braided and open (a marsh/shrub swamp complex with numerous dead standing trees), apparently the result of water backing up from the old "dam" downstream. Much of the open area had bur-reed (*Sparganium* sp.), water starwort (*Callitriche heterophylla*), and skunk cabbage (*Symplocarpus foetidus*). I wore my low rubber boots since it was a little cool in the morning, but soon went over them. Fortunately, it soon warmed up (in the 70's) and was a nice sunny day. For the most part, I tried to stay near the edge of the swamp in saturated to shallowly flooded areas, assuming they might be optimal for the swamp pink verses the deeper open areas. At one point as I struggled along, I looked up and low and behold there it was -- a swamp pink standing out above the skunk cabbage staring me in the face. My immediate reaction to myself was: 'Damn! Damn! There it is! I'll be damn!' Then I looked in another direction and only 20' from me was another one. I inspected the general area pretty thoroughly, doubling back and forth a few times and recorded a total of six clones (?), five of which had a flowering scape. Because of the dense skunk cabbage, however, I could have missed some other plants, particularly non-flowering ones."

I found the swamp pink in a red maple-black gum (*Acer rubrum-Nyssa sylvatica*) swamp just upstream from Lake Waterford on the north side of the floodplain, adjacent to what I have described in the past (Sipple 1993) as an apparent old lake bed or otherwise impounded area behind the existing lake. This impounded area has the remnants of a low dam and is mostly a shrub swamp/marsh complex with scattered standing dead trees. The most abundant and characteristic herb in the immediate vicinity of the swamp pink was the skunk cabbage (*S. foetidus*). The plants were in an area perhaps a tenth of an acre in extent and there was one flowering scape per cluster of plants. The flowering specimens had mature, greenish-brown, flaccid leaves; the adjacent ramets had clusters of younger, bright-green, erect leaves. I collected

data on the general plant community composition, as well as information on what I assumed were individual swamp pink clones.

I recorded the vascular plants in the general area, as well as the species rooted within a one-foot radius of the flowering scapes. I also took measurements on the individual plants. I opted not to collect one for obvious reasons, but did snip off one of the flaccid dying leaves, which I have retained. Only *Arisaema triphyllum* (jack-in-the-pulpit), *Uvularia sessilifolia* (sessile-leaf bellwort), and *Viola primulifolia* (primrose violet) were flowering at the time of my visit; the latter two species occurred on "drier" hummocks. My data are given below:

<u>List of plants in the general area</u>

*	*Nyssa sylvatica* (black gum)
*	*Acer rubrum* (red maple)
*	*Ilex opaca* (American holly)
*	*Clethra alnifolia* (sweet pepperbush)
*	*Symplocarpus foetidus* (skunk cabbage)
	Carex sp. (fine leaves)
	Carex sp. (broad leaves)
	Chelone glabra (?) (white turtlehead)
	Impatiens capensis (spotted touch-me-not)
	Viburnum nudum (possum-haw viburnum)
	Polygonum sagittatum (arrow-leaved tearthumb)
	Sambucus canadensis (elderberry)
	Rhododendron viscosum (swamp azalea)
+	*Lonicera japonica* (Japanese honeysuckle)
	Glyceria sp. (manna-grass)
	Rosa palustris (swamp rose)
	Osmunda cinnamomea (cinnamon fern)
	Woodwardia areolata (net-veined chain fern)
*	*Sparganium* sp. (bur-reed)
*	*Callitriche heterophylla* (water starwort)
+	*Rubus hispidus* (bristly blackberry)
*	*Leersia oryzoides* (rice cutgrass)
	Juncus sp. (rush)
	Mitchella repens (partridge-berry)
	Lycopus sp. (bugleweed)
	Mikania scandens (climbing hempweed)
	Dichanthelium sp. (panic-grass)
	Vaccinium corymbosum (highbush blueberry)
	Smilax rotundifolia (common catbrier)
	Magnolia virginiana (sweetbay)
	Arisaema triphyllum (jack-in-the-pulpit)
+	*Uvularia sessilifolia* (sessile-leaf bellwort)
+	*Viola primulifolia* (primrose violet)

* = dominants in respective strata, + = located on "drier" hummocks

Notes on individual swamp pink clones (Note: all associated plants were rooted)

#1 -- Five basal clumps of leaves counting the one flowering scape. Old leaves around flowering scape on this and all other clones listed below were greenish-brown and flaccid, lying on substrate. Other clumps had fresh bright-green, tightly clustered, but erect leaves less than 4" tall (all others described below had similar bright-green clustered leaves, but their heights varied). Scape, including flower cluster, 16" tall; flower cluster 1 3/4" long and 1 1/4" wide. Plant in 1-2" of standing (ponded) water. Within a 1' radius of scape was skunk cabbage, spotted touch-me-not, sedge (fine leaves), bur-reed, bugleweed, rice cutgrass, primrose violet, arrow-leaved tearthumb, sweet pepperbush, cinnamon fern, and an unidentified herb.

#2 -- Five basal clumps of leaves counting the one flowering scape. Old and new leaves as described above; new leaves less than 7" tall. This one was almost as tall as #1. Within a 1' radius, recorded skunk cabbage and sweet pepperbush. Swamp pink not on hummock.

#3 -- Three basal clumps; the one flowering scape, including flower cluster, 25" tall. Flower cluster 1 3/4" long and 1 1/4" wide. Found in 1" of water at edge of hummock. Plants within 1' radius included skunk cabbage, bristly blackberry, spotted touch-me-not, swamp azalea, and rice cutgrass.

#4 -- Two basal clumps, one flowering; the green, non-flowering clump less than 1" tall. Scape, including flower cluster, 11" tall; flower cluster 1 1/4" long and 1" wide. Located on edge of hummock, soil saturated but no standing water. Plants within a 1' radius included sedge (broad leaves), skunk cabbage, sweet pepperbush, partridge-berry, sessile-leaf bellwort, possum-haw viburnum, bristly blackberry, and spotted touch-me-not.

#5 -- Two clumps. One green and 2" tall; flowering scape only 5 1/2" tall, including flower cluster. Flower cluster 1 1/4" long and 1" wide. Located where draw tributary enters swamp. At edge of a hummock in 1/2" of water. Sweet pepperbush and spotted touch-me-not occurred within a 1' radius.

#6 -- One green clump about 3" tall and about 12" from # 5 above. Not flowering. Soil saturated, but no standing water. A sedge (broad leaves), sweet pepperbush, spotted touch-me-not, and bristly blackberry occurred within a 1' radius.

Although Brown and Brown (1984) listed the swamp pink as a rare Coastal Plain species, it was not listed by Reveal and Broome (1981) or Riefner and Hill (1983) in their articles on threatened and endangered plants in Maryland, and Reveal and Broome (1982) considered the species extirpated in the State. One the other hand, Thomas (1989) indicates that the swamp pink is known in Maryland from four locations -- two in Anne Arundel County and two in Cecil County. According to Kathy McCarthy of the Maryland Natural Heritage Program (personal communication), an additional site is known from Dorchester County. However, she reports no known historic or current records from the Lake Waterford area. I originally thought that Dr. Plitt had reported the swamp pink somewhere between Elvaton and Lake Waterford, which is where I found it. As it turns out, however, after re-reading Plitt's May 2, 1903 journal entry (Fessenden 1955), I now believe the site he described for the swamp pink was in the Marley Creek

drainage rather than above Lake Waterford. In addition, Plitt's April 29, 1905 entry (Kolb 1958) for Lake Waterford doesn't mention the swamp pink at or near that location. Thus, what I at first thought was a re-discovery, is apparently a new site for the swamp pink in Maryland, heretofore unknown to the botanical community.

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Reptiles and Amphibians of the Jug Bay Wetlands Sanctuary

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Abstract

A six-year study (1988-1993) of the herpetofauna was conducted at the Jug Bay Wetlands Sanctuary in Lothian, Anne Arundel County, Maryland (Latitude 38° 46'; Longitude 76° 42'). Drift fences with pitfall traps, annual censuses and casual field observations were used as survey methods. Thirty-nine species were observed: eleven snake, eight frog, seven salamander, seven turtle, three toad (plus one hybrid) and three lizard. Twenty-six species were found in both upland forest and non-tidal wetlands, and four species occurred almost exclusively in tidal wetlands. Of the 21 species captured in pitfall traps, marbled salamander, wood frog and spotted salamander were the most abundant. Numbers of these three species varied from year to year; the reasons for these fluctuations as well as the limitations of the drift fence with pitfall trap sampling techniques are discussed. An annotated species list with mensural data and natural history notes is also included. This on-going, long-term study is one of several ecological investigations coordinated by sanctuary naturalists. Studies are designed to monitor plant and animal populations, and to provide educational experiences for volunteers.

Introduction

Reptiles and amphibians are abundant vertebrates in Eastern deciduous forests. For example, Burton and Likens (1975) determined that salamander biomass (mainly attributed to a single species) was twice that of birds and equal to that of small mammals at the Hubbard Brook Experimental Forest, New Hampshire. Despite the apparent abundance and conspicuousness of amphibians, zoologists have documented worldwide declines in their populations during the past decade (Wake and Morowitz 1990, Wake 1991). Declines have been attributed to habitat destruction, introductions of predators and competitors, pesticide pollution, acid precipitation and global climate change (Wake 1991). Pechmann et al. (1991) have, however, emphasized that some amphibian population declines may be due to natural rather than anthropogenic causes. There are now a number of coordinated efforts to monitor amphibian populations and to share information among researchers (i.e., the *Frog Log*, published by the Declining Amphibian Populations Task Force - IUCN/SSC; Bishop and Pettit 1992).

There are approximately 80 species of reptiles and amphibians in the state of Maryland (Harris 1975, Conant and Collins 1991). Harris (1975) summarizes a wealth of information on the distribution of these animals in Maryland. The purpose of our on-going, long-term study is to characterize the reptile and amphibian community associated with wetland and upland habitats along the Patuxent River, to monitor population fluctuations of individual species, and to provide opportunities for volunteers to learn field ecology techniques. This paper describes the fauna, habitat utilization and population fluctuations for selected species within the Jug Bay Wetlands Sanctuary.

Study Area

Jug Bay Wetlands Sanctuary is a 200 hectare (500 acre) ecological field station located 29 km (18 miles) southwest of Annapolis on the edge of the Patuxent River in Anne Arundel

County, Maryland. The sanctuary is operated by the county Recreation and Parks Department. A portion of the sanctuary is within Maryland's Chesapeake Bay National Estuarine Research Reserve. Major habitats within the sanctuary are freshwater tidal wetlands, non-tidal wetlands, upland hardwood forests and agricultural fields (Figure 1). Common plants in the freshwater tidal wetland are cattail (*Typha latifolia*), spatterdock (*Nuphar advena*), common reed (*Phragmites australis*), arrowhead (*Sagittaria latifolia*), arrow arum (*Peltandra virginica*), wild rice (*Zizania aquatica*), smooth alder (*Alnus serrulata*) and green ash (*Fraxinus pennsylvanica*). Tuliptree (*Liriodendron tulipifera*), arrowwood (*Viburnum dentatum*), lizard's tail (*Saururus cernuus*), common greenbrier (*Smilax rotundifolia*), and black willow (*Salix nigra*) are common in the non-tidal wetland. American beech (*Fagus grandifolia*), tuliptree, oaks (*Quercus sp.*), Virginia pine (*Pinus virginiana*) and dogwood (*Cornus florida*) characterize the upland hardwood forest. Two permanent creeks drain the uplands and flow into Jug Bay. Two shallow temporary ponds, which fill with rainwater seasonally, were created when a railroad bed was built through the sanctuary in the 1890s. This study was mostly confined to the northern portion of the sanctuary.

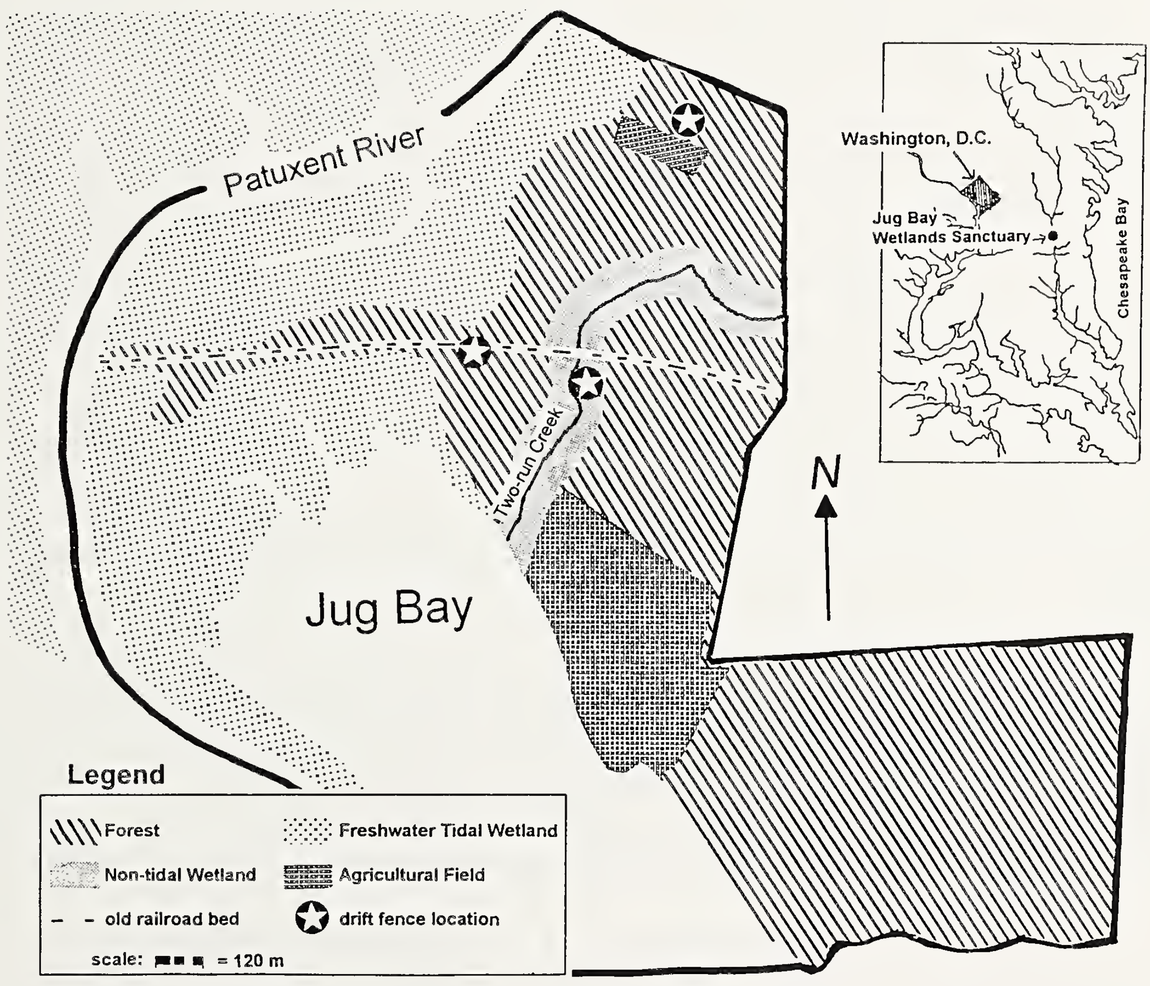

Figure 1. Map of Jug Bay Wetlands Sanctuary, Anne Arundel County, Maryland, showing major plant communities. Most observations reported here were made in the area north of Two Run Creek.

Methods

Populations were assessed using drift fences with pitfall traps, annual censuses, behavioral observations (mostly of nesting turtles) and casual field observations. Field data were collected by staff naturalists and by trained volunteers, most of whom attended training sessions to learn identification techniques, sampling procedures and standardized record keeping. Location of captured and/or sighted species was recorded. Weight was measured to the nearest 0.1 gram using a Pesola scale. Length was measured to the nearest millimeter using standard procedures: snout to vent (frogs and toads); snout to tip of tail (salamanders, lizards and snakes); or carapace length (turtles). Breeding aquatic salamanders were identified as males if they had a swollen vent. Animals were not marked for individual recognition. Almost all individuals were released shortly after capture. Staff naturalists reviewed all volunteer-collected field data to ensure accurate measurements and correct identifications. Rainfall and air temperature were measured daily at the sanctuary weather station.

Drift Fences with Pitfall Traps

In 1988 drift fences with pitfall traps were placed in three habitats: temporary pond, marsh edge and forest (Figure 1). The fences were constructed of 0.6 cm square mesh hardware cloth approximately 70 cm high and buried 10 cm in the soil. Pitfall traps were plastic buckets, 20 cm diameter by 17 cm deep (1988-1991), or 50 cm diameter by 45 cm deep (1991 to present). Buckets were buried midway along the length of the fence in order to capture animals traveling along either side of it. Traps were opened between February and May to capture breeding spotted salamanders and wood frogs, and between August and November to capture breeding marbled salamanders. Traps were opened for a period of two to four consecutive days and checked every morning. Damp sponges were placed in the traps to provide moisture for captured animals. Lids were placed over the traps when they were not in use. Data from the pitfall trapping are reported as numbers captured per trap-day multiplied by 100. A trap-day is equivalent to one functional trap open for one 24-hour period. Traps which filled with water or had the lip raised above the substrate because of saturated soil were considered non-functional and were not used in the analyses. Pitfall traps were opened for six fall and spring seasons (1988-1993) representing 3618 trap-days (187 spring days) and 1778 trap-days (101 fall days). Trapping effort is summarized in Table 1.

The Temporary Pond drift fence was 25.3 m in circumference and completely enclosed the pond. We used eight traps between 1988 and 1991, and four traps thereafter. Pond size varied seasonally (mean size was 6 x 8 m, maximum depth was 1 m) with maximum size occurring in the spring. The pond often dried by mid-summer but usually filled again in the fall. Depth of water in the pond was less in fall than in spring. The only vegetation in the pond was algae. Pond water pH was measured regularly with a Corning pH meter.

The Marsh Edge drift fence was linear and 13.5 m long. It was initially located in a tidal swamp at the edge of the freshwater tidal marsh, at a location dominated by *Phragmites*. In 1990 the fence and pitfalls were moved 35 m inland to a drier forested location to eliminate flooding by tidal waters. The new location was in a shallow, 14 meter-wide gulch in the old railroad bed. Six pitfalls were used between 1988 and 1991, and three pitfalls thereafter.

The Forest drift fence was placed in a low, seasonally-wet area. Each section of this cross-shaped fence measured 15.8 m. Flooding forced us to move the fence in spring 1990 to a slightly higher elevation. Twelve pitfalls were used between 1988 and 1991, and six thereafter.

Table 1. Distribution of pitfall trapping effort by year and season among the three trapping sites. TP= Temporary Pond, ME= Marsh Edge, WF= Wet Forest.

	Number of Trap-days			
	TP	**ME**	**WF**	**Total**
Spring Season				
1988	322	249	525	1096
1989	255	188	382	825
1990	137	104	165	406
1991	245	117	363	725
1992	125	52	210	387
1993	65	64	50	179
				3618
Fall Season				
1988	93	63	143	299
1989	145	121	260	526
1990	80	54	120	254
1991	24	18	36	78
1992	111	81	161	353
1993	73	67	128	268
				1778

Annual Censuses

Annual censuses (known as the "Great Herp Search") were held on June 3, 1989 (76 search-hours); June 2, 1990 (80 search-hours); June 8, 1991 (96 search-hours); June 13, 1992 (60 search-hours); and June 5, 1993 (134 search-hours). Censuses lasted four to six hours between mid-morning and mid-afternoon. Between 15 and 30 searchers participated in each census. Small groups led by a trained volunteer or staff member diligently searched assigned areas by turning over logs, inspecting the creek bottom or tidal channels and raking through leaf litter. Approximately 33 hectares of forest, four hectares of non-tidal wetlands and 2300 meters of shoreline adjacent to a tidal wetland were searched on each census. Volunteers attempted to capture, identify and measure all specimens encountered. All sightings were plotted on a map.

Turtle Watch and Casual Observations

Turtle nesting activity was studied in May and June of 1988. Turtles were located by walking routes in known nesting areas. The route was walked in morning and afternoon. Nest location, habitat descriptions and turtle behavior were noted. Turtles in the process of ovipositing were not disturbed.

Another source of information used in this report was the sanctuary logbook, a compilation of wildlife sightings by staff, volunteers and visitors.

Results

A total of 751 reptile and amphibian records and observations were made by 200 volunteers and eight staff naturalists. Thirty-nine species of reptiles and amphibians were identified within the study site: eleven snake, eight frog, seven salamander, seven turtle, three toad (plus one hybrid) and three lizard species (Table 2). The most commonly observed species were green frog, wood frog, American toad, Fowler's toad, marbled salamander, spotted salamander, fence lizard, eastern box turtle, eastern painted turtle, redbelly turtle and black rat snake. Rarely observed species were gray treefrog, upland chorus frog, eastern mud salamander, four-toed salamander, northern red salamander, northern two-lined salamander, spotted turtle, queen snake and northern brown snake.

Most species (27) were found in both upland and non-tidal wetland habitats (Table 2). Only four species occurred in all three habitats. Several species (i.e. turtles and migratory salamanders) were found in certain habitats only during breeding or nesting seasons.

A total of 306 individuals representing 27 species were encountered during the five annual censuses (Table 3). The highest daily species count on these censuses was 21 in 1990 (Figure 2). Search effort did not appear to affect the number of species encountered. The search effort in 1993 (134 search-hours) was more than double that in 1992 (60 search-hours), yet only one additional species was encountered.

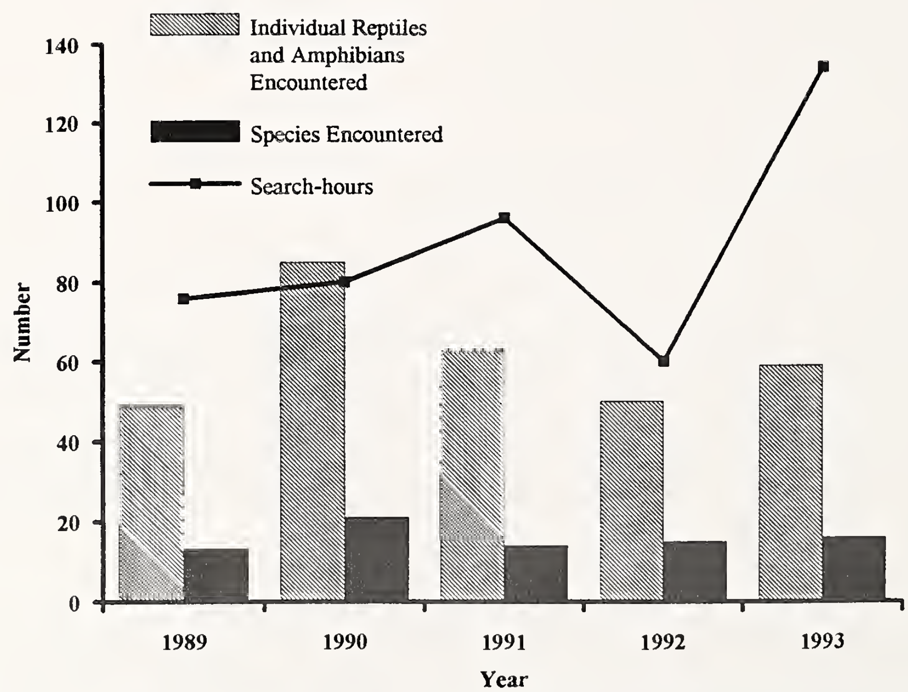

Figure 2. Amount of search effort and number of reptiles and amphibians encountered during annual censuses at Jug Bay Wetlands Sanctuary.

Table 2. Species of reptiles and amphibians observed at the Jug Bay Wetlands Sanctuary, with distribution by major plant community.

Species	Upland Forest	Non-tidal Wetlands	Tidal Wetlands
Green Frog (Rana clamitans melanota)	X	X	X
Wood Frog (R. sylvatica)	X	X	
Bullfrog (R. catesbeiana)	X	X	
Pickerel Frog (R. palustris)		X	X
Southern Leopard Frog (R. utricularia)		X	X
Spring Peeper (Pseudacris crucifer)	X	X	X
Upland Chorus Frog (P. triseriata feriarum)		X	X
Gray Treefrog (Hyla chrysoscelis / H. versicolor)	X	X	X
American Toad (Bufo americanus)	X	X	
Fowler's Toad (B. woodhousii fowleri)	X	X	
American\Fowler's Toad (Bufo americanus x B. woodhousii fowleri)	X	X	
Eastern Spadefoot Toad (Scaphiopus holbrookii holbrookii)	X	X	
Marbled Salamander (Ambystoma opacum)	X	X (B)	
Spotted Salamander (A. maculatum)	X	X (B)	
Redback Salamander (Plethodon cinereus)	X	X	
Eastern Mud Salamander (Pseudotriton montanus montanus)	X	X	
Northern Red Salamander (P. ruber ruber)	X	X	
Four-toed Salamander (Hemidactylium scutatum)	X	X	
Northern Two-lined Salamander (Eurycea bislineata)		X	
Fence Lizard (Sceloporus undulatus)	X		
Five-lined Skink (Eumeces fasciatus)	X	X	
Six-lined Racerunner (Cnemidophorus sexlineatus sexlineatus)	X		
Eastern Box Turtle (Terrapene carolina carolina)	X	X	
Eastern Painted Turtle (Chrysemys picta picta)	X (B)		X
Redbelly Turtle (Pseudemys rubriventris)	X (B)		X
Snapping Turtle (Chelydra serpentina)	X (B)	X	X
Stinkpot (Sternotherus odoratus)	X (B)	X	
Eastern Mud Turtle (Kinosternon subrubrum subrubrum)	X (B)	X	
Spotted Turtle (Clemmys guttata)	X (B)	X	
Black Rat Snake (Elaphe obsoleta obsoleta)	X	X	
Rough Green Snake (Opheodrys aestivus)	X	X	
Eastern Worm Snake (Carphophis amoenus amoenus)	X		
Northern Water Snake (Nerodia sipedon sipedon)		X	X
Northern Black Racer (Coluber constrictor constrictor)	X	X	
Eastern Hognose Snake (Heterodon platirhinos)	X		
Northern Ringneck Snake (Diadophis punctatus edwardsii)	X		
Eastern Kingsnake (Lampropeltis getula getula)	X	X	
Queen Snake (Regina septemvittata)			X
Northern Brown Snake (Storeria dekayi dekayi)	X	X	X
Eastern Garter Snake (Thamnophis sirtalis sirtalis)	X	X	

X (B) = occurs in this habitat during breeding season only

Table 3. Species and number of individuals of reptiles and amphibians encountered on annual censuses at Jug Bay Wetlands Sanctuary.

	Year				
Species Observed	**1989**	**1990**	**1991**	**1992**	**1993**
Green Frog (Rana clamitans melanota)		3	20	12	6
Wood Frog (R. sylvatica)	10	2	3	1	7
Bullfrog (R. catesbeiana)	1			1	1
Pickerel Frog (R. palustris)	1		1	1	1
Spring Peeper (Pseudacris crucifer)		1			1
American Toad (Bufo americanus)	9	12	4	1	
Fowler's Toad (B. woodhousii fowleri)	12	6	3	2	
American\ Fowler's Hybrid		5	2		9
Marbled Salamander (Ambystoma opacum)		2			
Spotted Salamander (A. maculatum)			1		
Northern Two-lined Salamander (Eurycea bislineata)					1
Fence Lizard (Sceloporus undulatus)	4	9	9	12	6
Five-lined Skink (Eumeces fasciatus)	3	3	3	5	
Six-lined Racerunner (Cnemidophorus sexlineatus sexlineatus)	1	4	2		1
Eastern Box Turtle (Terrapene carolina carolina)	3	15	10	1	10
Eastern Painted Turtle (Chrysemys picta picta)	2	2	1	4	1
Redbelly Turtle (Pseudemys rubriventris)		2		1	
Snapping Turtle (Chelydra serpentina)		2			3
Stinkpot (Sternotherus odoratus)					4
Eastern Mud Turtle (Kinosternon subrubrum subrubrum)		3		1	
Black Rat Snake (Elaphe obsoleta obsoleta)		2	1	3	1
Rough Green Snake (Opheodrys aestivus)	1	2			
Eastern Worm Snake (Carphophis amoenus amoenus)		5	1		5
Northern Water Snake (Nerodia sipedon sipedon)	1	1	2	4	2
Eastern Hognose Snake (Heterodon platirhinos)		2			
Eastern Kingsnake (Lampropeltis getula getula)	1				
Queen Snake (Regina septemvittata)		1		1	
Eastern Garter Snake (Thamnophis sirtalis sirtalis)		1			
Totals	**49**	**85**	**63**	**50**	**59**

Approximately 50% of all species observed in the sanctuary were captured in the pitfall traps (Table 4). Sixteen of 18 amphibian species and six of 21 reptile species were captured in traps.

The marbled salamander was encountered primarily during the August-November breeding season (Figure 3A). Peak numbers were captured in traps between mid-September and the first week of October. Only 10.1% of 101 sightings were made at other times of the year (March, April and June). The pitfall capture rate for marbled salamanders was twice as high in September (mean = 11.6, sd = 19.7) as in October (mean = 5.8, sd = 9.8). Marbled salamanders were captured in approximately the same abundance at the Temporary Pond (41 captures) and Forest (51 captures) sites during all breeding seasons combined (Figure 4A). Marbled salamanders were not captured at the Marsh Edge site.

Table 4. Species and number of captures in pitfall traps at Jug Bay Wetlands Sanctuary.

Species	Captures
Marbled Salamander	92
Wood Frog	92
Spotted Salamander	88
American, Fowler's or Hybrid Toad	59
Green Frog	20
Eastern Spadefoot Toad	15
Snapping Turtle	10
Eastern Mud Turtle	9
Spring Peeper	5
Redback Salamander	4
Southern Leopard Frog	3
Five-lined Skink	3
Eastern Mud Salamander	2
Eastern Worm Snake	2
Four-toed Salamander	1
Northern Red Salamander	1
Bullfrog	1
Pickerel Frog	1
Fence Lizard	1
Northern Ringneck Snake	1
Total Captures	**410**

The spotted salamander was observed primarily during the February-April breeding season (Figure 3B). Only 3% of 99 sightings were made at other times of the year. These sightings were in June and October in forested areas, either from traps or in and under rotting logs. The pitfall capture rate for spotted salamanders was five times as great in March (mean = 7.4, sd = 18.1) as in February (mean = 1.5, sd = 3.6) and almost seven times as great as in April (mean = 1.1, sd = 2.8). Temporary Pond was the preferred breeding habitat (Figure 4B); a total of 74 captures were made there compared to eight in the Marsh Edge and six in the Wet Forest traps.

Wood frogs were captured most often in the pitfall traps during the February-April breeding season, but were sighted through August. The peak capture rate occurred in March (Figure 3C). The maximum number captured at one time was 29 on 7 March 1992 at the Temporary Pond site. Wood frogs appeared to prefer the flood plain and Temporary Pond habitat to the forest or marsh edge. Of 124 total sightings, 94% were at the pond site or on the surrounding flood plain. The only sighting or capture in the forest occurred in spring 1993, a very wet season when approximately 1 meter of water accumulated in a depressed region surrounding the drift fences.

Eastern painted turtles and redbelly turtles were seen commonly in the intertidal channels during the warmer months, either basking on logs or swimming. Snapping turtles, eastern mud turtles and stinkpot turtles also inhabited the tidal wetland although they were not often seen owing to their retiring habits. Eastern box turtles were seen almost entirely in the uplands and only rarely along the upper edge of the marsh. The wetland species were restricted entirely to the tidal wetland habitat, except when females traveled up to several hundred meters inland to

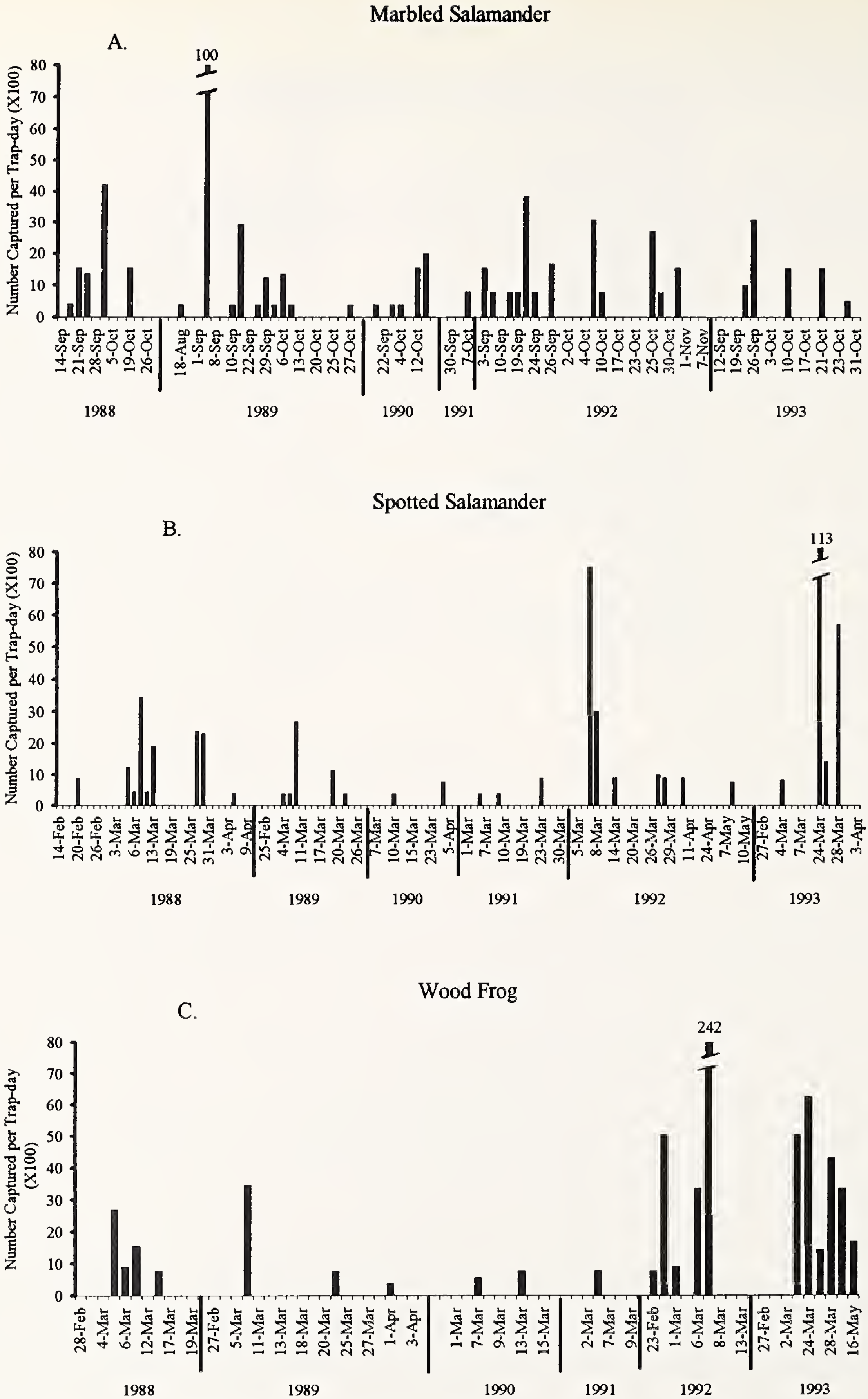

Figure 3. Capture rates for marbled salamanders (A), spotted salamanders (B), and wood frogs (C) during breeding seasons, all sites combined. A trap day is equivalent to one functional trap open for one 24 hour period. A, N= 1778 trap-days; B, N= 3618 trap-days; C, N= 3618 trap-days.

excavate nests and lay eggs. We often discovered nest depressions with dried eggshells scattered on the surface indicating predation, probably by raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), Virginia opossum (*Didelphis virginiana*) or striped skunk (*Mephitis mephitis*).

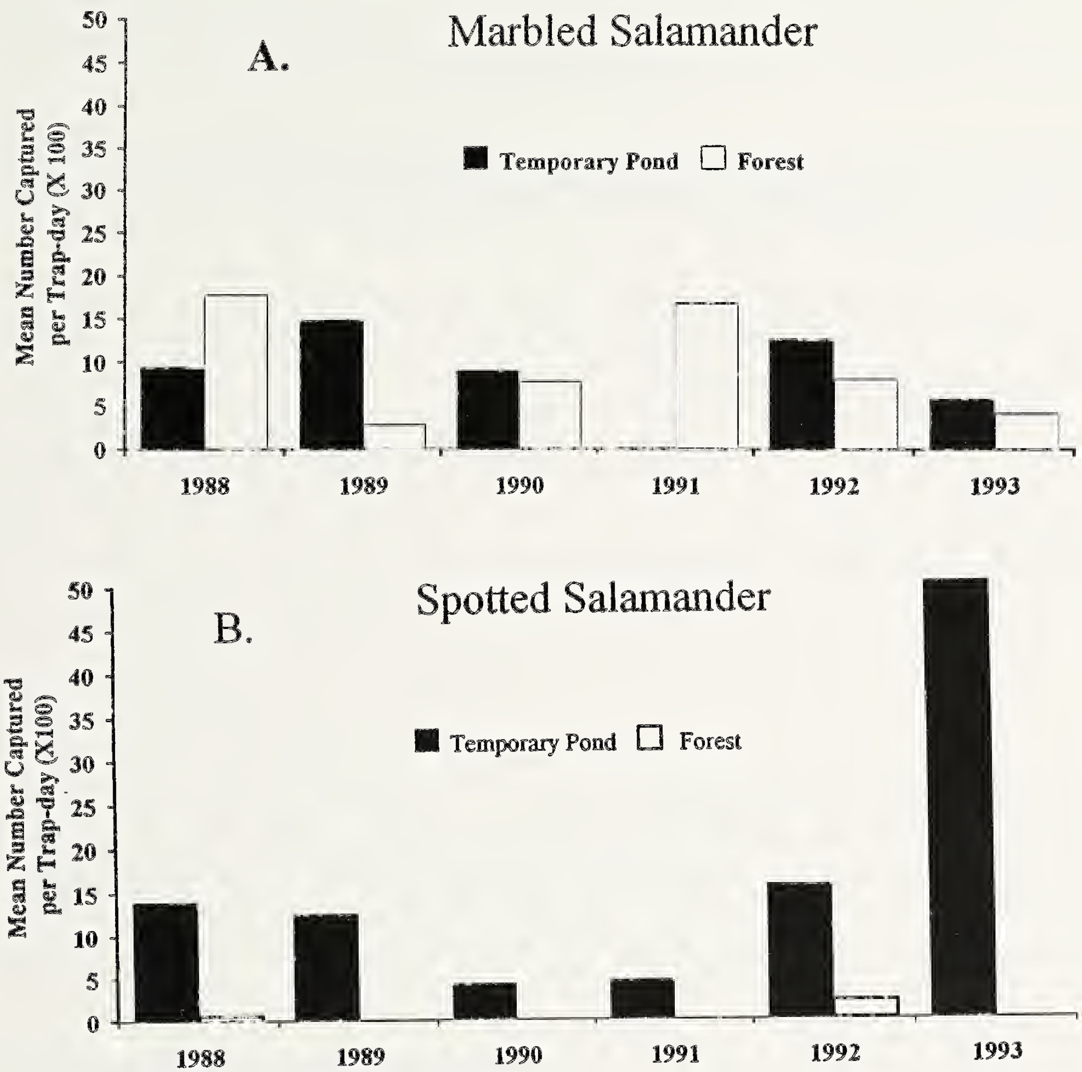

Figure 4. Mean numbers of marbled and spotted salamanders captured per trap-day (x 100). A trap-day is equivalent to one functional trap open for one 24-hour period. A, number of marbled salamanders captured at Temporary Pond and Forest Sites. B, number of spotted salamanders captured at Temporary Pond and Forest Sites.

We made a special effort to correctly identify American toads and Fowler's toads because they are very similar in appearance and are known to hybridize. We distinguished between these species by noting three characteristics: number of warts per spot, tibial wart size and proximity of parotid gland to cranial ridge (Conant and Collins 1991). Nonetheless, a large percentage of individuals could not be identified. The American toad appears to be more common than either the Fowler's toad or hybrids, however, the precise population composition could not be determined.

Three species of lizards were recorded in our study. Fence lizards and six-lined racerunners were confined mostly to fences bordering the parking area, and graveled areas around dwellings. Five-lined skinks were found on building roofs, parking lot fences, marsh boardwalks and in the forest.

Species List

Mensural data and natural history notes are summarized below for each species. Species are classified as common if there were six or more total sightings, or uncommon if there were five or fewer total sightings.

Frogs and Toads

Green Frog *(Rana clamitans melanota)*
Common. Earliest sighting was 10 March 1990, latest was 31 October 1992. Mean length was 5.8 cm (n=62, range 3.0 - 7.0 cm). Mean weight was 21.4 g (n=58, range 2.4 - 59.0).

Wood Frog *(Rana sylvatica)*
Common. Earliest sighting was 23 February 1992, latest was 30 September 1989. Breeding activity observed in February, March and early April. Large numbers were occasionally captured during breeding season. Trapped frogs were often found in amplexus and one female even laid eggs in a pitfall trap. Mean length was 4.8 cm (n=94, range 3.1 - 6.9 cm). Mean weight was 11.3 g (n=74, range 2.5 - 27.0 g).

Spring Peeper *(Pseudacris crucifer)*
Common. Often heard calling on spring days, and warm winter days - earliest vocalization was on 31 December 1992. Mean length was 2.6 cm (n=7, range 1.2 - 3.3 cm). Mean weight was 3.2 g (n=7, range 1.0 - 7.0 g). A 1.2 ha stand of *Phragmites* in the tidal wetland appeared to support a dense concentration of spring peepers.

Bullfrog *(Rana catesbeiana)*
Common. Earliest sighting was 18 April 1993. Mean length was 7.1 cm (n=7, range 4.7 - 10.5 cm). Mean weight was 53.3 g (n=6, range 10.0 - 128.0 g).

Pickerel Frog *(Rana palustris)*
Common. Earliest sighting was 4 May 1993, latest was 20 October 1993. Mean length was 4.9 cm (n=4, range 3.5 - 6.0 cm). Mean weight was 11.5 g (n=4, range 5.0 - 17.0 g).

Southern Leopard Frog *(Rana utricularia)*
Uncommon. Earliest sighting was 20 February 1988, latest was 10 October 1993. Mean length was 4.9 cm (n=4, range 4.0 - 5.2 cm). Two frogs, measuring 4.0 and 5.1 cm, weighed 6.0 and 13.0 g, respectively.

Gray Treefrog *(Hyla chrysoscelis / H. versicolor)*
Uncommon. Single individuals sighted in April and July 1990. These frogs were 4.0 and 4.7 cm in length, and weighed 12.0 and 4.0 g, respectively.

Upland Chorus Frog *(Pseudacris triseriata feriarum)*
Uncommon. The single record on 6 March 1993 was based on a vocalization from within a stand of *Phragmites* in the tidal wetland. Spring peepers were also calling at the time.

American Toad *(Bufo americanus)*
Common. Earliest sighting was 6 February 1990, latest was 25 October 1992. Mean length was 5.5 cm (n=82, range 1.6 - 10.0 cm). Mean weight was 18.5 g (n=83, range 0.5 - 52.0 g).

Fowler's Toad *(Bufo woodhousii fowleri)*
Common. Earliest sighting was 25 April 1990, latest was 15 September 1989. Mean length was 4.4 cm (n=30, range 2.6 - 7.0 cm). Mean weight was 12.5 g (n=29, range 3.5 - 48.0 g).

American/Fowler's Toad Hybrid *(Bufo americanus* x *Bufo woodhousii fowleri)*
Common. Earliest sighting was 7 March 1992, latest was 25 September 1993. Mean length was 5.0 cm (n=12, range 2.4 - 12.0 cm). Mean weight was 12.1 g (n=10, range 2.0 - 42.0 g).

Eastern Spadefoot Toad *(Scaphiopus holbrookii holbrookii)*
Common. Earliest sighting was 30 March 1991, latest was 19 October 1988. Mean length was 3.4 cm (n=15, range 2.3 - 6.3 cm). Mean weight was 6.6 g (n=16, range 1.0 - 23.0 g). Young toadlets were seen in the fall and three were found in a single pitfall trap on 4 September 1993.

Salamanders

Marbled Salamander *(Ambystoma opacum)*
Common during fall breeding season. Earliest sighting was 18 August 1989, latest was 5 December 1993. The maximum captured in a single pitfall trap was three in a Forest trap on 4 October 1988; a total of ten were captured in all Forest traps on that day. Mean male length was 12.1 cm (n=26, range 9.9 - 13.5 cm), mean male weight was 10.1 g (n=26, range 6.0 - 19.0 g). Mean female length was 11.0 cm (n=26, range 7.0 - 14.0 cm), mean female weight was 10.9 g (n=25, range 3.2 - 18.0 g). Additional measurements of unsexed individuals: mean length = 11.2 cm (n=38, range 3.7 - 19.0 cm), mean weight = 10.5 g (n=36, range 1.0 - 21.0 g).

Spotted Salamander *(Ambystoma maculatum)*
Common during spring breeding season. Earliest sighting was 20 February 1988, latest was 8 May 1992. The maximum captured in a single pitfall trap was five on 24 March 1993; a total of nine were captured in all Temporary Pond traps on that day. Mean male length was 16.3 cm (n=39, range 8.5 - 20.0 cm), mean male weight was 20.7 g (n=38, range 10.0 - 39.0 g). Mean female length was 15.6 cm (n=26, range 8.0 - 25.0 cm), mean female weight was 21.4 g (n=25, range 12.5 - 39.0 g). Additional measurements of unsexed individuals: mean length = 15.8 cm (n=32, range 10.2 - 24.0 cm), mean weight = 18.0 g (n=32, range 8.0 - 30.0 g).

Redback Salamander *(Plethodon cinereus)*
Common. Earliest sighting was 4 March 1989, latest was 20 December 1990. Of sixteen individuals in which stripe color was noted, ten had red stripes and six had lead-colored stripes. Mean length was 7.3 cm (n=30, range 3.8 - 10.5 cm). Mean weight was 1.6 g (n=21, range 0.2 - 15.0 g).

Eastern Mud Salamander *(Pseudotriton montanus montanus)*
Uncommon. The two individuals observed were in the railroad bed gulch on 11 March and 24 April 1988. These salamanders measured 15.3 and 17.2 cm and weighed 16.0 and 20.0 g.

Northern Red Salamander *(Pseudotriton ruber ruber)*
Uncommon. A single individual captured in the forest on 6 October 1989 measured 10.5 cm and weighed 8.0 g.

Four-toed Salamander *(Hemidactylium scutatum)*
Uncommon. A single individual captured in the forest on 21 April 1989 measured 7.3 cm and weighed approximately 1.0 g.

Northern Two-lined Salamander *(Eurycea bislineata)*
Uncommon. A single individual captured next to Two-run Creek in the flood plain on 5 June 1993 measured 4.5 cm and weighed 4.0 g.

Lizards

Fence Lizard *(Sceloporus undulatus)*
Common. Often sighted on parking lot fences or in adjacent leaf litter. Observed from March through September, and occasionally on warm winter days. Mean length was 12.4 cm (n=27, range 6.0 - 17.0 cm). Mean weight was 7.9 g (n=23, range 1.0 - 19.5 g).

Five-lined Skink *(Eumeces fasciatus)*
Common. Often sighted on parking lot fences, building roof and boardwalk. Observed from March through October, and occasionally on warm winter days. Male breeding colors seen in May and June. Mean length was 11.8 cm (n=14, range 6.5 - 17.0 cm). Mean weight was 7.1 g (n=10, range 1.5 - 14.0 g).

Six-lined Racerunner *(Cnemidophorus sexlineatus sexlineatus)*
Common. Often sighted on the parking lot and in adjacent areas of open ground. Observed from spring to fall. Young were seen in June and July. Mean length was 15.1 cm (n=3, range 13.0 - 19.0 cm). Two lizards measuring 13.3 and 19.0 cm, weighed 3.0 and 6.0 g, respectively.

Turtles

Eastern Box Turtle *(Terrapene carolina carolina)*
Common. Active from April through October. Young were observed in early June. No nesting or egg-laying observed. Noted eating mushrooms and prickly pear cactus (*Opuntia humifusa*). Of the 30 individuals that were sexed, 74.2 % were males. Adult male mean carapace length was 13.1 cm (n=19, range 9.0 - 16.5 cm), mean weight was 363.4 g (n=11, range 293.0 - 481.0 g). Adult female mean carapace length was 11.6 cm (n=7, range 10.0 - 13.0 cm). Weights for two adult females (both 13.0 cm in length) were 373.2 and 485.0 g. Two young measured 4.5 and 5.0 cm, and their mean weight was 7.5 g.

Eastern Painted Turtle *(Chrysemys picta picta)*
Common. Sighted April through October, and on warm winter days (one was seen on 19 January 1990). Nest construction and egg-laying observed between 25 May and 14 July. If disturbed while digging, turtles often retreated from the area. One female dug for 80 minutes. Another used her hind feet to adjust and apparently pack the eggs tightly together. Mean adult weight was 488.5 g (n=3, range 360.0 - 680.4 g), mean adult carapace length was 14.2 cm (n=16, range 10.0 - 20.0 cm). Hatchlings observed in mid April and in June. Mean carapace length for hatchlings was 5.3 cm (n=3, range 4.0 - 7.0 cm). Weight for one hatchling was 10.0 g.

Redbelly Turtle *(Pseudemys rubriventris)*
Common. Sighted April through October, and on warm winter days. Nest construction and egg-laying observed 30 May through 14 July. Of the 23 records, 74% were of females sighted on land during the egg-laying period. If disturbed during nest construction females often stopped and abandoned nests. Some females observed for extended periods made several nests, only one of which contained eggs. One turtle spent 35 minutes building a nest and 35 minutes covering it after laying eggs. Mean carapace length for females was 27.2 cm (n=9, range 8.3 -32.0 cm). One hatchling captured on 2 June 1990 had a carapace length of 5.3 cm and weighed 7.5 g.

Snapping Turtle *(Chelydra serpentina)*
Common. Nest construction and egg-laying observed in May, June and July. Four hatchlings were seen in Temporary Pond - two in October 1988, one in May 1993, and one in June 1993. Mean carapace length for adult females was 31.8 cm (n=4, range 23.0 - 50.0 cm), mean weight was 4134.0 g (n=2, range 2268.0 - 6000.0 g). Mean carapace length for young was 4.1 cm (n=4, range 2.9 - 7.0 cm), mean weight was 17.1 g (n=4, range 7.5 - 42.0 g).

Eastern Mud Turtle *(Kinosternon subrubrum subrubrum)*
Common. Earliest sighting was 26 March 1988, latest was 8 September 1991. A female seen 8 September 1991 was laying eggs. Young were seen in early June. Mean adult carapace length was 8.9 cm (n=15, range 8.0 - 11.0 cm), mean weight was 132.1 g (n=10, range 51.0 - 268.0 g). Mean carapace length of young was 3.3 cm (n=3, range 3.2 - 3.3 cm), and the weight of one young turtle was 50.0 g.

Stinkpot Turtle *(Sternotherus odoratus)*
Uncommon. The five sightings were all in June. Nest building was not observed. Mean carapace length was 10.4 cm (n=4, range 10.0 - 11.5 cm). Two females, measuring 10.0 and 11.5 cm, weighed 175.0 and 182.0 g, respectively.

Spotted Turtle *(Clemmys guttata)*
Uncommon. An injured individual was found 30 April 1988 on the floodplain of Two-run Creek. Carapace length was 10.1 cm, weight was 160.0 g.

Snakes

Black Rat Snake *(Elaphe obsoleta obsoleta)*
Common. Earliest sighting was 16 February 1990, latest was 30 November 1992. On 13 June 1992 two were seen coiled together in an arrowwood shrub, possibly engaged in courtship. On 22 March 1990 one was seen pursuing white-footed mice (*Peromyscus leucopus*) in a dead tree. Black rat

snakes were also seen entering eastern bluebird (*Sialia sialis*) nest boxes. Mean length was 108.8 cm (n=13, range 30.0 - 186.0 cm). Mean weight was 668.8 g (n=5, range 78.0 - 1360.8 g).

Northern Water Snake *(Nerodia sipedon sipedon)*
Common. Often seen basking on logs in the tidal wetlands on warm days. Earliest sighting was 13 January 1992, latest was 31 December 1992 (both days had unseasonably warm temperatures). Mean length was 66.2 cm (n=9, range 22.0 - 100.0 cm). Mean weight was 103.7 g (n=3, range 6.0 - 260.0 g).

Rough Green Snake *(Opheodrys aestivus)*
Common. Often seen in small trees and shrubs. Earliest sighting was 17 April 1993, latest was 23 October 1992. Mean length was 52.5 cm (n=6, range 20.5 - 72.0 cm). Mean weight was 12.6 g (n=4, range 1.5 - 20.0 g).

Eastern Worm Snake *(Carphophis amoenus amoenus)*
Common. Earliest sighting was 19 April 1991, latest was 10 October 1992. A copulating pair (11.5 and 12.0 cm) was found on 2 June 1990 under a piece of bark. Young snakes seen in April and May. Mean length was 15.5 cm (n=17, range 1.5 - 24.5 cm). Mean weight was 3.7 g (n=12, range 2.0 - 6.5 g).

Eastern Hognose Snake *(Heterodon platirhinos)*
Common. One individual lived under a house porch for two months in the spring. Earliest sighting was 11 January 1990, latest was 17 June 1990. Mean length was 62.7 cm (n=3, range 58.0 - 70.0 cm). One 58.0 cm individual weighed 115.0 g.

Northern Black Racer *(Coluber constrictor constrictor)*
Uncommon. Earliest sighting was 13 April 1992, latest was 12 October 1990. Mean length was 126.1 cm (n=3, range 50.3 - 182.9 cm). Two individuals measuring 50.3 and 145.0 cm weighed 17.0 and 597.0 g, respectively.

Northern Ringneck Snake *(Diadophis punctatus edwardsii)*
Uncommon. The four sightings were in a field and the railroad bed gulch. Earliest sighting was 9 May 1990, latest was 24 September 1992. Mean length was 24.9 cm (n=3, range 10.0 - 35.0 cm). Mean weight was 4.6 g (n=3, range 1.0 - 6.5 g).

Queen Snake *(Regina septemvittata)*
Uncommon. The three individuals observed were in the tidal wetland. Earliest sighting was 30 April 1988, latest was 13 June 1992. These three measured 17.0, 27.0, and 47.0 cm. The 17.0 cm snake weighed 2.0 g.

Eastern Kingsnake *(Lampropeltis getula getula)*
Uncommon. The three sightings were all from the field or lawn. Earliest sighting was 22 May 1992, latest was 28 June 1991. Two individuals measured were 93.0 and 150.0 cm in length. The 93.0 cm snake weighed 266.0 g.

Eastern Garter Snake *(Thamnophis sirtalis sirtalis)*
Uncommon. The three sightings were all in the forest near the marsh. Sightings were in March

1992 and 1993, and June 1990. One snake regurgitated a toad while being handled. Mean length was 45.1 cm (n=3, range 23.5 - 59.8 cm). Two individuals measuring 52.0 and 59.8 cm weighed 35.0 and 22.5 g, respectively.

Northern Brown Snake *(Storeria dekayi dekayi)*

Uncommon. The two observed were seen in the tidal wetland. One was seen 5 June 1991, and the other on 11 July 1992.

Discussion

The 39 species documented within our study area represents 71% of the 55 species of reptiles and amphibians expected to occur there based on published range maps (Harris 1975, Conant and Collins 1991). The remaining 16 species could occur in the study site but have not been found. Five of these species are normally conspicuous but have never been observed here: green treefrog (*Hyla cinerea*), tiger salamander (*Ambystoma tigrinum*), copperhead (*Agkistrodon contortrix),* broadhead skink (*Eumeces laticeps*) and diamondback terrapin *(Malaclemys terrapin).* These species probably are absent from the study site. Seven species have secretive habits and may actually be present: ground skink (*Scincella lateralis),* scarlet snake (*Cemophora coccinea)*, corn snake (*Elaphe guttata),* mole kingsnake *(Lampropeltis calligaster),* eastern milksnake *(Lampropeltis triangulum),* smooth earth snake *(Virginia valeriae)*, and northern redbelly snake (*Storeria occipitomaculata).* Finally, four other species may be present but our field work may not have focused on the proper habitats: cricket frog (*Acris crepitans)*, red-spotted newt (*Notophthalmus viridescens*), dusky salamander (*Desmognathus fuscus)* and ribbon snake (*Thamnophis sauritus).* We plan to expand our field work in the future to determine the status of these species within the study area.

North American amphibian populations are regulated primarily by environmental conditions such as rainfall that ultimately effect egg survivorship and larval development. Pechmann et al. (1991) in a long-term study of tiger and mole salamanders concluded that populations of these migratory species were controlled mostly by rainfall during the breeding season. A relationship may also exist between our spotted and marbled salamander capture rates and rainfall. During the study period spotted salamander capture rates for the Temporary Pond site ranged from a mean low of 4.2 (1990) to a mean high of 50 captured per trap-day (1993). The low capture rate in spring 1990 appeared to be related to low rainfall in February and March (total of 11.7 cm), that was 4.6 cm below normal. The high capture rate in spring 1993 was during a very wet period (23.4 cm of rain in February and March), more than 7.9 cm above normal (Jug Bay unpublished data). The mean capture rate for marbled salamanders at the Temporary Pond was highest in 1989, at 14.8 per trap-day. This was also the wettest fall on record with 31.0 cm of rainfall, or 13.2 cm above normal. In fall 1991 the pond was dry for the entire breeding season (total rainfall for September and October was 18.3 cm). We did not capture any marbled salamanders in the Temporary Pond traps during that season.

A relationship may also exist between rainfall and breeding site selection in marbled salamanders at Jug Bay. The lowest mean capture rate at the forest was in fall 1989 (2.8), the same year the mean capture rate for the pond was highest (14.8). The lowest mean capture rate at Temporary Pond was in fall 1991, the same time we recorded the second highest mean capture rate

for the forest (16.7). The preferred breeding habitat may be ponds during years of normal or above normal rainfall, but during years of low rainfall other habitats such as the forest may be used. Spotted salamanders, however, did not appear to shift habitats from the pond to the forest during years of drought.

In addition to rainfall, population size can also be controlled by features of the aquatic environment where eggs and larvae develop. Dissolved oxygen concentration, pH, water temperature and seasonal pond longevity affect the survivorship of spotted salamander eggs (Albers and Prouty 1987). There has been a growing awareness of the acid rain problem and its potential effect on amphibians. Many frogs and salamanders breed in small temporary ponds where they are especially vulnerable because inflowing water is poorly buffered. Acid precipitation resulting in low pond pH causes decreased egg survival and inhibits larval development (Pierce 1985, Albers and Prouty 1987, Portnoy 1990). Pierce (1985) determined that pH levels below 5 resulted in 50% mortality in Jefferson salamanders *(Ambystoma jeffersonianum)*, smallmouth salamanders *(A. texanum)*, and spotted salamanders. We measured pH in Temporary Pond between March 1991 and October 1993. Although mean pH was 5.4 (sd=0.56; n=93), pH levels were less than 5 in March 1991, between March and April 1992, and through most of spring 1993, the season when many amphibians breed. We have not attempted to document egg survivorship for those species that breed in Temporary Pond (spotted salamander, marbled salamander and wood frog), although that could be a focus for future research.

Although drift fences with pitfall traps are frequently used to estimate population size, this method has limitations because not all reptiles and amphibians that encounter them are captured. Some small animals can crawl through fences made of hardware cloth, some individuals can crawl over or burrow under fences, and large or agile species can escape from pitfall traps. Green frogs, pickerel frogs, bullfrogs, spring peepers, other treefrogs and most snakes are capable of escaping from the traps. Dodd (1991) noted that pine woods treefrogs *(Hyla femoralis)*, eastern narrowmouth toads (*Gastrophryne carolinensis*) and striped newts *(Notophthalmus perstriatus)* were all able to climb over or tunnel under drift fences made of aluminum flashing. Although our drift fences were buried in the soil to discourage passage underneath, it is possible that small or juvenile individuals passed through the 0.6 cm hardware cloth. This mesh size is a concern at the Temporary Pond site where juvenile salamanders leave the water after completing larval development.

Gibbons and Semlitsch (1981) noted that fences, due to their orientation and the location of traps, may not intercept established home ranges or migration routes. The result could be a biased estimate of population fluctuation or size. The fence and traps surrounding the Temporary Pond site are probably catching most of the individuals that use this habitat. The cross-shaped Forest fence and the straight-line Marsh Edge fence, however, may not be intercepting all individuals traversing these areas. In both sites reptiles and amphibians could gain access to the area without encountering a fence.

Long-term studies such as this one can make essential contributions to ecology. We plan to continue long-term monitoring and will be erecting drift fences with pitfall traps in additional forest locations, around several more ponds, and in the non-tidal wetland. We will be implementing a system for individually recognizing salamanders to obtain a measure of population size and density. We also plan to increase the number of "Great Herp Searches" in order to better determine the presence and abundance of rare or undocumented species. The information summarized here is a baseline from which to chart future changes in population size and species composition.

Acknowledgements

This study was initiated by Christine Gault following the advice of James Lynch, Anson Hines and Dennis Whigham of the Smithsonian Environmental Research Center. Field work was coordinated at various times by Holly Budd, Liz McClunin, and Susana Martin. Other assistance was provided by Doris Peters, Mark Peabody and Tim Thoman. Principal volunteers who helped with the field work were Joyce Casebeer, George Zinkgraf, Woody Martin, Jim Harle, Todd Blanc and Robert Frezza. Susan Blackstone, Kathy Boeckman and Jean Hershner helped summarize data. James Lynch, William Grogan, David Lee and Marilyn Fogel provided helpful comments on the manuscript. Thanks are also due to all 200 volunteers who have helped over the years.

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NATURAL HISTORY SOCIETY OF MARYLAND, INC.
2643 North Charles Street
Baltimore, Maryland 21218

The Maryland Naturalist

THE NATURAL HISTORY SOCIETY OF MARYLAND

Volume 38, Number 1-2 Jan./June 1994

ISSN 0096-4158

The Maryland Naturalist

Volume 38, Number 1-2 Jan./June 1994

Contents

Arnold W. Norden, Editor

Mailing Date: 29 July 1994

Cover Illustration: *Hydrilla verticillata*, reproduced from an illustration in *Economically Important Foreign Weeds: Potential Problems in the United States* by Dr. Clyde F. Reed (U.S. Department of Agriculture, Agriculture Handbook No. 498, 1977). This composite figure shows a typical plant with details of the leaf, pistillate and staminate flowers, and seeds.

Female Feral Dog and Two Pups Kill Deer Fawn at the Patuxent Wildlife Research Center, Laurel, Maryland

Nicholas E. Federoff, Wanda J. Jakob,
and Wayne C. Bauer

On 23 November 1992 (0830 hr) an adult female feral dog (*Canis lupus familiaris*) and two pups (5-6 months old) were observed stalking several white-tailed deer (*Odocoileus virginianus*) in an open field at the Patuxent Wildlife Research Center (Center) in Laurel, Maryland. The adult dog (a mixed breed, ~23-27 kg) was observed taking down a deer fawn in a fashion consistent with that of the grey wolf (*Canis lupus*) (Mech 1970, 1991). The entire stalk-chase-kill sequence took no more than 5-10 minutes. The fawn (~27 kg) was pulled down by an attack to the nose and throat area. The pups excitedly bit at the fawn's hind quarters while the adult opened the abdomen. Mech (1991) noted similar behavior by grey wolves, and reported that once they had incapacitated prey, its undersides were immediately torn open and its entrails eaten. Young fawns are easy prey for feral dogs and pups as young as 4 months of age are apparently capable of maintaining chase with adult pack members (Cude 1977). The female and pups, after observing us, retreated into the woods. The wounded fawn ran about 20 meters into a marsh area where it died (probably by drowning or excessive hemorrhage). The fawn was retrieved from the marsh and wounds to the face and throat area were evident, as was an open abdominal cavity.

Dogs can be classified as domestic or tame, free ranging, and feral or wild. Perry and Giles (1970) further classify dogs as domestic, surplus, free-running, stray, drop-offs, and feral. Scott (1971) defines a feral dog as one that does not associate or receive care from humans. McKnight (1964) further defined feral animals as those that were once domesticated but which are no longer receiving protection, care, or food from humans. The female and pups observed by us were believed to be feral based on their hunting, stalking, and killing behavior and an obvious flight distance when approached. The pups, as old as they were, probably were born in the wild. Judging from their behavior, it seems unlikely that these dogs were receiving any care from humans. The deer were not chased haphazardly or harassed in any way but were deliberately stalked. Once the individual deer was selected from the herd, a short chase ensued and the fawn was attacked. This behavior is consistent with the descriptions in (Mech 1975).

The Center, technically classified as a Wildlife Research Refuge, has a large protected white-tailed deer population that presents much potential prey for dogs. Limited hunting is permitted on the 8100-acre North Tract of the Center to reduce deer numbers. Immunocontraception (Kirkpatrick et al. 1992) has been proposed as a possible population control method. Although the Center has a chain-link fence on much of its border, dogs can easily gain access to the area. Dogs are occasionally observed on the Center and several deer mortalities have been attributed to dogs over the past few years. This, however, is the first documented observation of dogs killing deer on the Center.

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Some Observations on Hydrilla and Wintering Waterfowl in Montgomery County, Maryland

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Introduction

Biologists have recognized that some aquatic plants frequently categorized as pests are beneficial to wildlife. Florschutz (1973) documented extensive utilization of Eurasian milfoil *(Myriophyllum spicatum)* as food by waterfowl in Back Bay, Virginia and Currituck Sound, North Carolina. Others have documented that hydrilla infested waters are attractive to fish, waterfowl, and a variety of wildlife (Moxely and Langford 1982, Kilgore et al. 1988, Hardin et al. 1984, Hurley 1990). Johnson and Montalbano (1987) argued that a growing body of published evidence suggests hydrilla is especially attractive to wintering waterfowl. The objective of this study was to examine the relationship between hydrilla *(Hydrilla verticillata)* and wintering waterfowl at two sites in Montgomery County, Maryland.

Background

Hydrilla is a submerged, aquatic macrophyte native to Africa and Southeast Asia (Traver et al. 1978, Hurley 1990). It first appeared in the United States in Florida about 1960 via the aquarium trade (Haller 1978). Since then, hydrilla has become established in at least 12 other states including Maryland and the District of Columbia (Brown and Brown 1984, Johnson and Montalbano 1987, Hurley 1990). Hydrilla was first detected in the freshwater tidal portion of the Potomac River near Washington, D.C. in 1982 (Hammerschlag 1988) and by 1989 covered approximately 3,002 acres (1,215 ha) of shallow shoreline habitat (Hurley 1990). It also occurs on the Susquehanna Flats of the upper Chesapeake Bay but is much less abundant there than in the lower Potomac (Hurley 1990).

Hydrilla's growth form is freely branching and prolific. Its leaves are linear to lanceolate, have serrated margins, a prominent spinous midrib, and occur in whorls of three to eight; the stipules are fringed (Gleason and Cronquist 1991, Reed 1977). Hydrilla was initially misidentified in Florida as *Elodea sp.*, a common water plant of the central and northern states (Haller 1978). Hydrilla can be differentiated from that species by its sharply serrated leaf margins, red veins, spinous midrib, and scabrous texture (Traver et al. 1978). However, as noted by Haller (1978), leaf morphology, number of leaves per node, and general appearance of the plants varies among localities, making misidentification possible.

Gleason and Cronquist (1991) note that hydrilla is monoecious or dioecious. The first plants introduced into Florida were dioecious females (Haller 1978) whereas the strain occurring locally in the Chesapeake Bay region is monoecious (Hurley 1990). The female flowers are small, 0.16-0.20 inches (4-5 mm) across, white, have three petals, arise singularly from a spathe near the growing tips of the stems (Traver et al. 1978), and are born on a hypanthium at the water's surface (Hurley 1990). The male flowers are small, white (Traver et al. 1978) and have

three stamens (Gleason and Cronquist 1991, Reed 1977). When mature, the male flowers detach from the stem, float to the surface and shed their pollen into the air. The pollen must settle directly on a female flower for pollination to take place (Hurley 1990).

Hydrilla is capable of propagating by seed, from stolons and rhizomes, fragmentation, and from turions and tubers (Traver et al. 1978, Hurley 1990). However, seed set is normally less effective than vegetative reproduction (Hurley 1990). Traver et al. (1978) note that turions, or winter buds, are dense clusters of apical leaves produced in leaf axils. Tubers, on the other hand, are located at the ends of rhizomes. Both of these structures allow hydrilla to survive cold winters in temperate regions (e.g., northeastern United States) and to endure periods of drought (Traver et al. 1978).

Hydrilla is predominately a freshwater species tolerating salinity concentrations of up to 6-9 ppt (Traver et al. 1978, Hurley 1990). Hydrilla grows well at light levels of only 0.5-1.0 % full sunlight (Haller 1978, Traver et al. 1978) enabling it to grow at greater depths and in more turbid water than most native submergents. Hydrilla also tends to grow to the surface, creating thick mats or beds of vegetation. These mats effectively shade out competitors and often leave hydrilla the dominant species (Traver et al. 1978, Kilgore et al. 1988).

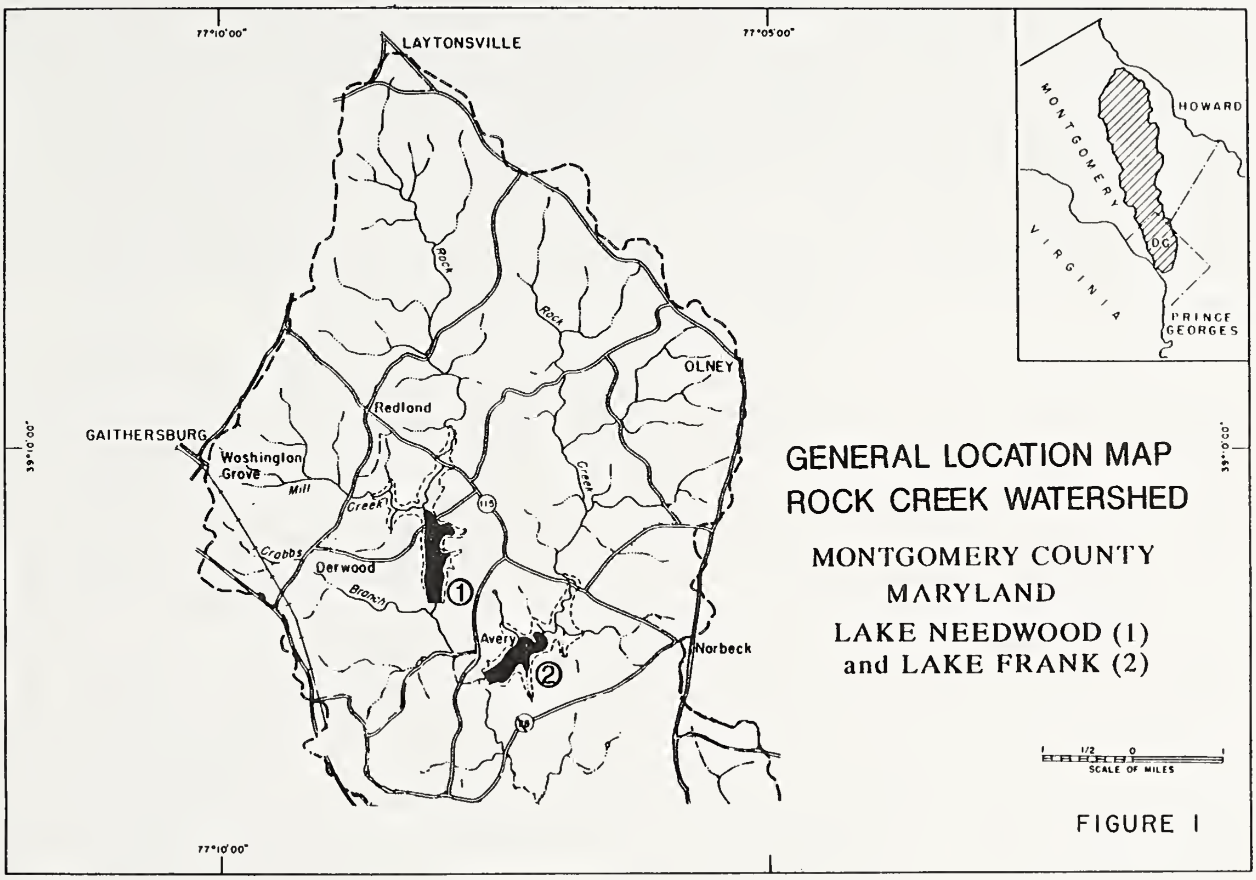
Materials and Methods

The Setting

Montgomery County, Maryland, covers about 316,160 acres (128,000 ha), lies immediately north of Washington, D.C., and is bounded on the west and southwest by the Potomac River. About 97 % of the county lies on Maryland's Piedmont; a small area along the county's eastern boundary lies on the Coastal Plain. Long, narrow stream valleys drain the county's gently rolling topography. Elevations range from approximately 200 feet (61 m) near the District of Columbia to 699 feet (213 m) in the north. Bedrock in the western part of the county consists of layers of sandstone, shale, siltstone, and conglomerate. The remainder of the county is underlain by parallel belts of metamorphic rock, mostly phyllite, schist, gneiss, serpentinite, or greenstone (Froelich 1975). Ninety-two percent of the county's soils occur on uplands. The remaining soils occur on floodplains or on old, high terraces along the Potomac River (Matthews et al. 1961, U.S. Department of Agriculture 1990). The natural vegetation of Montgomery County is primarily hardwood forest (Brush et al. 1980).

In the early 1960s the U.S. Department of Agriculture, Soil Conservation Service, constructed Lake Needwood (58.0 acres, 23.5 ha) and Lake Frank (53.8 acres, 21.8 ha) in Rock Creek Regional Park, Montgomery County (Figure 1). The lakes were constructed under the authority of the Watershed Protection and Flood Prevention Act (PL-566, 83rd Congress, 68 Stat. 666) as amended, and were intended to provide watershed protection, flood retention, sediment control, and recreation for about 32 % of the Rock Creek Watershed (Anonymous 1962). Presently, Lake Needwood is open for recreational boating (May through September) and fishing, whereas Lake Frank is open only to fishing.

Figure 1. Map of Rock Creek watershed, Montgomery County, Maryland, showing location of Lake Needwood and Lake Frank.



Methods

In 1984 and 1985, low altitude, color aerial photographs of Lake Needwood and Lake Frank were taken with a 35 millimeter single-lens-reflex camera from a single engine, fixed-wing aircraft by park staff. These photographs were used to assess the presence/absence and extent of beds of submerged aquatic vegetation (SAV) in the lakes. With the aid of a canoe, submerged aquatic plants were sampled in late June of 1984 and 1985 to determine species composition.

From November 29, 1984 through January 8, 1985, and November 26 through December 17, 1985, 16 waterfowl inventories were conducted at each of three standardized locations (forebay, protected cove, approximate center) on each lake. The inventories were carried out by an observer and data recorder between 0700 and 0930 hours with the aid of 7 x 35 binoculars and a 20X spotting scope. Prior to each inventory, a random drawing was held to determine the order in which the six locations were surveyed. Randomization was used to balance the time effect on inventories across locations. An effort was made to obtain an exact count of each species present.

Results and Discussion

Color aerial photographs of Lake Needwood revealed SAV totaling about 41 acres (16.6 ha) in 1984 and 42.5 acres (17.2 ha) in 1985. No SAV was observed on the photographs of Lake Frank in either year. Canoe surveys revealed three species of SAV in Lake Needwood: hydrilla, water-purslane *(Ludwigia palustris)*, and sago pond-weed *(Potamogeton pectinatus)*. Hydrilla grew in large monotypic beds that formed a dense canopy at the water's surface and it was by far the dominant species of SAV in the lake. Water-purslane and sago pond-weed were found widely interspersed with hydrilla in a few shallow shoreline areas. Although not visible on the photographs, three species of SAV were found during the canoe surveys of Lake Frank: water-purslane, sago pond-weed, and coontail *(Ceratophyllum demersum)*. These plants were found in small patches in shallow water along some areas of the lake shore.

The presence/absence of SAV beds affected the diversity and abundance of waterfowl using the two lakes (Table 1). Seventeen species and 6,681 individuals were recorded during the 16 waterfowl inventories. However, the total number of species and total number of individuals were not evenly distributed between the two lakes. Fourteen species and 5,887 individuals were observed on Lake Needwood; eight of those species were not seen on Lake Frank. Nine species and 794 individuals were observed on Lake Frank; three of those species (represented by a total of five individuals) were not seen on Lake Needwood. All of the Canada geese *(Branta canadensis)*, gadwall *(Anas strepera)*, American wigeon *(Anas americana)*, canvasback *(Aythya valisineria)*, and bufflehead *(Bucephela albeola)*, as well as significantly more mallard *(Anas platyrnchos)*, ring-necked duck *(Aythya collaris)*, lesser scaup *(Aythya affinis)*, and ruddy duck *(Oxyura jamaicensis)* were observed on Lake Needwood. Six of 17 waterfowl species were common to both Lakes: mallard, American black duck *(Anas rubripes)*, ring-necked duck, lesser scaup, common goldeneye *(Bucephela clangula)*, and ruddy duck. Of these, black duck was more abundant on Lake Frank. Horned grebe *(Podiceps auritus)*, pied-billed grebe (*Podilymbus podiceps)*, tundra swan *(Cygnus columbianus)*, wood duck *(Aix sponsa)*, common goldeneye, hooded merganser *(Lophodytes cucullatus)*, and American coot *(Fulica americana)* were represented by less than five individuals across both lakes.

Stewart and Robbins (1958:38-39) indicate relative abundance for wintering waterfowl species in each of Maryland's biotic provinces. Ten of 17 species observed in the present study were classified by the aforementioned authors as rare on the Piedmont: gadwall, American wigeon, wood duck, canvasback, ringnecked duck, lesser scaup, bufflehead, hooded merganser, ruddy duck, and American coot; three were classified as uncommon: Canada goose, American black duck, and common goldeneye; one was considered fairly common: mallard; and two were considered casual (*i.e.*, a species, slightly beyond its range for the season indicated, was recorded very few times): horned grebe and pied-billed grebe. Data collected from Lake Frank are consistent with these classifications whereas data from Lake Needwood are not (Table 1).

As noted previously, both Lake Needwood and Lake Frank are located in the Rock Creek watershed and cover approximately the same surface area. Further, the greatest distance between the two lakes is only about two miles (3.2 km). What does set these two bodies of water apart is the presence of extensive SAV beds -- composed almost entirely of hydrilla -- in Lake Needwood, and the absence of similar beds in Lake Frank.

Table 1. Results of 16 waterfowl inventories conducted on Lake Needwood and Lake Frank, Montgomery County, Maryland, from November 29, 1984 through January 8, 1985, and November 26, 1985 through December 17, 1985.

Species	Lake Needwood	Lake Frank	Total
Canada Goose	2,931	-	2,931
Ring-necked Duck	1,710	172	1,882
Mallard	857	550	1,407
Bufflehead	109	-	109
Lesser Scaup	102	2	104
Canvasback	93	-	93
American Black Duck	28	59	87
Ruddy Duck	17	4	21
Gadwall	17	-	17
American Wigeon	15	-	15
Wood Duck	3	-	3
Common Goldeneye	1	2	3
Hooded Merganser	-	3	3
Tundra Swan	2	-	2
American Coot	2	-	2
Horned Grebe	-	1	1
Pied-billed Grebe	-	1	1
	5,887	794	6,681

This study demonstrates the positive value of SAV, and in particular hydrilla, to waterfowl that winter on Maryland's Piedmont. Similarly, the importance of hydrilla to waterfowl has been noted in other areas of the eastern United States. Montalbano et al. (1978), Montalbano et al. (1979), O'Meara et al. (1982), and Hardin et al. (1984) demonstrated that hydrilla is an important food for ducks, coots, and common moorhens *(Gallinula chloropus)* in Florida. Gasaway et al. (1977) attributed declines in waterfowl numbers in Lake Wales, Florida, to declines in hydrilla abundance. Hurley (1990) noted that hydrilla has contributed to an increase in waterfowl numbers on the tidal Potomac River.

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Solidago (Asteraceae) in Maryland II: The Literature

Haven Kolb

Introduction

In the first section of a continuing study of the genus *Solidago* (sensu stricto) in Maryland (Kolb 1991), I presented information on the county distribution of the species based entirely on herbarium specimens that I had collected myself or personally studied in several herbaria. While this procedure established responsibility for the data, it ignored the fact that there is a body of literature that records the studies of other investigators. Though that body is not large and does not contain any items devoted exclusively to the genus, it seems worthwhile to review it, to place it into historical context, and to attempt to establish a concordance of nomenclature. These are the purposes of the present paper.

History of Maryland Solidago Records

No doubt the aborigines of the country had their own knowledge of goldenrods, but they had no literature. And, for some time after the invasion of their land by people from the eastern side of the Atlantic, the newcomers were too busy to write about plants of no apparent utility or even to notice them. Eventually, however, persons who themselves, in most cases, remained on the eastern side of the ocean became sufficiently curious about what they referred to as the "natural productions" of the transatlantic lands to commission others to send back to them specimens of what they found there. Although there was some earlier activity in Virginia, the first such emissary arrived in Maryland about three centuries ago: July 22, 1696 (Frick et al. 1987).

This cleric-botanist, Hugh Jones, survived the rigors of colonial Maryland only a short time, but he did send back some specimens to his sponsors. And other collectors, arriving soon after him, did the same. From these materials the earliest printed accounts of Maryland plants derived. In one of these (Petiver 1698) occurred what is probably the first published mention of a Maryland goldenrod: what is now known as *Solidago odora* L. (Broome et al. 1987).

In the years before Linnaeus established the binomial system of nomenclature in 1753, the presence in Maryland of eight of the now recognized species of *Solidago* had been documented (Brown et al. 1987). In the latter part of the eighteenth century, however, activity in Maryland was confined to a few short visits by botanists on their way elsewhere.

The establishment of the nation's capital in the District of Columbia, formerly a part of Maryland, eventually brought to that area persons with botanical interests, who as early as 1819 began to publish on the local flora. With the passage of time and the increase in the size of the city of Washington, these botanists extended their explorations of the flora beyond the District line into Maryland and Virginia, so that it sometimes becomes difficult now to determine which of their records from the District area refers to which of the three political divisions.

In the Baltimore area, interest in local floristics has been sporadic. Apparently the first listing of the flora was that by Aikin (1837). A more complete list was that of Basil Sollers (1888). In the 1930's effort was made to combine the Baltimore and Washington areas (and a part of northern Virginia) in a floristic project; it succumbed to the exigencies of the Second World War, but not before it produced two editions of a mimeographed list (Hermann 1941 and 1946). In addition, two county plant lists have been published (Redmond 1932 and Stieber 1971).

The first attempt at covering the flora of the entire state was that of Shreve (1910). More recently Brown and Brown have produced an illustrated flora in two volumes, of which the one on herbaceous plants (1984) is apropos to the present paper. It also contains a somewhat more extensive account of Maryland botanical history.

Finally, Maryland plant records have occurred in a number of scattered papers. Those that pertain to *Solidago*, so far as I have been able to discover them, are mentioned below in reference to the appropriate species.

Published Maryland *Solidago* Records

In this list numbered binomials are the names of species recognized by Gleason and Cronquist (1991), except for the addition of *S. altissima.*

1. *Solidago altissima* L.

According to Reveal et al. (1987b) this name was based by Linnaeus on an illustration that was itself based on a garden plant grown in London from Maryland seed.

In Aikin (1837), Ward (1881), and Sollers (1888) the binomial refers to what is now termed *S. rugosa* Mill. (q.v.). However, in most later literature it refers to *S. altissima* L. as described in Brown and Brown (1984). Gleason and Cronquist (1991) regarded this entity as a variety of *S. canadensis* L. (q.v.), as did Reveal et al. (1987b).

Only Hermann (1946) listed var. *procera* (Ait.) Fern., which is not recognized by Gleason and Cronquist (1991).

2. *Solidago arguta* Ait.

Under this name Ward (1881) remarked, "The earliest flowering species of our Golden Rods." and he did not list *S. juncea*, so it is clear that he misidentified it, as had Sollers (1888). See *S. juncea* below.

Stieber (1971) listed *S. arguta* for Anne Arundel County with a notation indicating a specimen in the Langlois Herbarium (Catholic University), which, unfortunately, has now been dispersed. This is an addition to my county records (Kolb 1991). Brown and Brown (1984) remarked, "Infrequent on the Coastal Plain." but gave no details. The remark may be based on

Tatnall (1946), but Tatnall explicitly restricted his listing to Cecil County, where the plant occurs in the Piedmont portion. Following Gleason and Cronquist (1991), I include *S. harrisii* Steele as a variety under *S. arguta*. Likewise under *S. arguta* is placed var. *caroliniana* (see below under *S. boottii*).

Solidago aspera Ait.

This species was listed in Norton and Brown (1946). It is now considered infraspecific to *S. rugosa* (q.v.).

3. *Solidago bicolor* L.

Some of the surviving specimens collected in the 17th and early 18th centuries have been identified as this species (Reveal et al. 1987a, Brown et al. 1987). This is an abundant plant, listed in all the major Maryland floristic treatments and occurring in all of the physiographic provinces. Ward (1881) and Sollers (1888) listed also var. *concolor* T. & G., now considered to be *S. hispida* (q.v.).

Solidago boottii Hook.

This name was listed by Brown and Brown (1984) with reference to "Allegany County" and under it both Fernald (1950) and Gleason (1952) explicitly referred to Maryland. However, the name has been shown to belong to a lower Mississippi Valley variety of *S. arguta*. The plants referred to by the authors cited above are *S. arguta* var. *caroliniana* Gray. [q.v., not *S. caroliniana* (L.) BSP!]

4. *Solidago caesia* L.

As with *S. altissima*, Linnaeus based *S. caesia* on an illustration that was probably itself based on a garden specimen grown from Maryland seed; the polynomial that accompanied the illustration contained the words "Marilandica" and "caesia" (Reveal et al. 1987b). Like *S. bicolor*, which it often accompanies in the field, *S. caesia* was mentioned in all the principal Maryland floristic treatments. Both Brown and Brown (1984) and Tatnall (1946) noted that it is less common on the Coastal Plain than elsewhere. Stieber (1971) added Anne Arundel to my county list (Kolb 1991).

5. *Solidago canadensis* L.

This binomial can include var. *scabra* T. & G., which I have treated as *S. altissima* above. Reveal et al. (1987a and 1987b), in their study of pre-Linnaean Maryland plants referred all the *S. canadensis* specimens except one to var. *scabra*. The exception is a specimen in the Du Bois herbarium collected by Vernon (slightly later than Hugh Jones) that they listed as *Solidago canadensis* L. var. *canadensis*. However, Cronquist (1980) states, "Typical *S. canadensisis* northeastern and is not known in our [southeastern] range" --which included Maryland. Nor have I seen any; all have been var. *hargeri* Fern.

The earlier writers, up to and including Hitchcock and Standley (1919), simply recorded the species. Judging by present conditions, most of the material they collected was probably var. *scabra* (here considered S. *altissima*). Among later writers, Hermann (1946) under *S. canadensis* wrote "also *Hargeri*" and Norton and Brown (1946) listed the binomial and also var. *hargeri*. Brown and Brown (1984), in addition to the binomial, listed var. *hargeri* and also var. *scabra* --possibly an error, for they do not state how they distinguished between var. *scabra* and *S. altissima*, which they also listed. Moreover, they had var. *rupestris* (Raf.) Cronq. -- listed at specific rank below. Norton and Brown (1946), on authority of Deam (1940), listed var. *gilvocanescens* Rydb., a prairie entity that has been recorded a few times in the east.

And finally, there is *S. elongata* Nutt., reported by Stieber (1971) from Anne Arundel County. Not recognized as a full species for over a century, this entity is synonymized by Gleason and Cronquist (1991) with *S. canadensis* var. *salebrosa* (Piper) Jones with a distribution in the Rocky Mountains and southern Canada.

Solidago caroliniana (L.) BSP

This name in Tatnall (1946) refers to an entity here considered to belong to the genus *Euthamia.*

Solidago concolor T. & G.

This name in Shreve (1910) refers to what is here treated as *Solidago hispida* Muhl. (q.v.).

6. *Solidago curtisii* T. & G.

Cusick (1986) has reported this southern Appalachian species from Garrett County.

7. *Solidago elliottii* T. & G.

Sollers (1888) listed this species (under the name *Solidago elliptica* Ait. [q.v.]), but apparently only in reference to Ward (1881), where it could have referred to Virginia. Tatnall (1946) and others referred to it on the Eastern Shore. The first definite reference I find on the Western Shore is Hotchkiss and Stewart (1947); it could apply to either Anne Arundel or Prince Georges Counties. However, Brown and Brown (1986) definitely listed Prince Georges, an addition to the counties in my list (Kolb 1991). All Maryland records seem to apply to var. *ascendens* Fern.

Solidago elliptica Ait.

This name, used by Sollers (1888) for *S. elliottii* T. & G., was misapplied by him as by some other authors in the 19th century.

Solidago elongata Nutt.

Reported by Stieber (1971); see under *S. canadensis* above.

8. *Solidago erecta* Pursh

This species does not seem to be mentioned in the Maryland *Solidago* literature until Hitchcock and Standley (1919), probably having been confused with similar species. However, most later authors listed it, for it is widespread. Both Tatnall (1946) and Brown and Brown (1984) mentioned Talbot County, an addition to my (Kolb 1991) county list.

9. *Solidago fistulosa* Mill.

This is another species that does not appear in the Maryland 19th century literature. However, unlike *S. erecta*, it is not widespread, but an inhabitant of the Coastal Plain. All the references I have found in the literature have been to the Eastern Shore counties; the Anne Arundel County record that I have reported (Kolb 1991) is based on a single specimen collected by C. C. Plitt in 1902.

10. *Solidago flexicaulis* L.

Linnaeus (1753) described this species and immediately thereafter *S. latifolia* with the notation "Nimis affinis S. flexicauli..." i.e., very much related to *S. flexicaulis*. The word "Nimis" can also mean "too much" and eventually that is what botanists have decided. However, Aikin (1837) still listed both names and Ward (1881), Sollers (1888), and even Tatnall (1946) used *latifolia*, the last with the cryptic note"(*S. flexicaulis* L., in part.)". Shreve (1910) and all later authors cited herein, except Tatnall, used *flexicaulis*. There are no records from the Coastal Plain.

11. *Solidago gigantea* Ait.

In the literature here under review this species was first listed by Ward (1881). It was referred to by Sollers (1888), Shreve (1910), and Hitchcock and Standley (1919) as *S. serotina* (q.v.). All later authors used *S. gigantea*. Anne Arundel (Stieber 1971) is an addition to the counties listed in Kolb (1991). (The listing in Hotchkiss and Stewart [1947] could apply to either Anne Arundel or Prince Georges.) There are no records for this species in the southernmost counties of either the Eastern or Western Shores.

The var. *leiophylla* Fern. was listed by most authors, either directly or indirectly. See below under *S. serotina*.

Solidago graminifolia (L.) Salisb.

This species, listed in many Maryland references, is here considered to belong in the genus *Euthamia*.

Solidago gymnospermoides (Greene) Fern.

This name, listed in Tatnall (1946), is here considered to belong to an entity in the genus *Euthamia*.

Solidago harrisii Steele

This binomial is used by Norton and Brown (1946) and Brown and Brown (1984). See under *S. arguta* above.

12. *Solidago hispida* Muhl.

A specimen in the Du Bois Herbarium at Oxford collected by Vernon, a contemporary of Hugh Jones, has been identified as this species (Reveal et al. 1987a)

Ward (1881) and Sollers (1888) listed this species under the name *S. bicolor* var. *concolor* and Shreve (1910) under the binomial *S. concolor*. Later authors used *S. hispida*. Worcester (Redmond 1932) is an addition to the counties listed in Kolb (1991); it is the only mention of the species on the Eastern Shore.

13. *Solidago juncea* Ait.

Ward (1881) did not list *S. juncea*, but under *S. arguta* remarked, "...earliest flowering species." This clearly points to *juncea*. Sollers (1888) referred to Ward, but did not quote the remark. Aikin (1837) listed neither species and *S. juncea* was not among the materials from the Maryland collectors of the 17th and 18th centuries. Shreve (1910) remarked, "...infrequent." I have found it in every county of the state except Calvert. One wonders whether its status may not have greatly changed in the last 150 or so years.

The var. *scabrella* (T. & G.) Gray was listed by Hermann (1946) and Norton and Brown (1946) and the var. *ramosa* Porter and Britton by Hermann (1946). Neither is recognized by Brown and Brown (1984) nor by Gleason and Cronquist (1991).

Solidago laevigata Ait.

Listed in Aikin, this is an old synonym for *S. sempervirens* (q.v.).

Solidago latifolia L.

This binomial, listed in Aikin (1837), Ward (1881), Sollers (1888), and Tatnall (1946), refers to *S. flexicaulis* (q.v.)

Solidago ludoviciana (Gray) Small

Only Tatnall (1946) listed this species and he did not clearly refer it to the Maryland portion of the Eastern Shore. It should be sought. (*Solidago tarda* Mackenzie in Gleason and Cronquist [1991].)

Solidago marilandica Mill.

According to Reveal et al. (1987a, 1987b) Miller based this name on a figure in Martyn (1729) with the polynomial, "Virga aurea Marilandica, spicis florum racemosis, foliis integris,

scabris". The figure was based on garden material grown from seed from Maryland. Its polynomial was synonymized by Linnaeus (1753) with his *S. altissima* (q.v.).

Solidago microcephala (Greene) Bush

This name, occurring in Tatnall (1946), Norton and Brown (1946) and Brown and Brown (1984), refers to an entity here considered to belong to the genus *Euthamia*.

Solidago missouriensis Nutt.

The mention of this western species by Brown and Brown (1984) seems to rest entirely upon specimens in the Fessenden Herbarium in Baltimore. These are *S. juncea* (Kolb 1991).

Solidago monticola T. & G.

Shreve (1910) listed this species and Chrysler (1910) mentioned it as characteristic of his "Mountain Zone". Fernald (1950) maintained it as a variety of *S. roanensis* Porter; Gleason and Cronquist (1991) synonymized it with that species (q.v.).

Solidago neglecta T. & G.

Hitchcock and Standley (1919) and Norton and Brown (1946) used this name for what is now considered to be *S. uliginosa* (q.v.).

14. *Solidago nemoralis* Ait.

Found in every county of the state (Kolb 1991), this species appeared in all the major references since Ward (1881) as well as in Redmond (1932) and Stieber (1971).

15. *Solidago odora* Ait.

In the herbaria at the British Museum and at Oxford there are several specimens of this species (Reveal et al. 1987a). These specimens were cited by Brown et al. (1987) in discussing plants of colonial Maryland that are at present considered rare. In my researches in the tidewater counties, however, I found it in most, but remarked, "The current lack of material from western Maryland is incompatible with evidence from Virginia and Pennsylvania" (Kolb 1991). All the major references from Aikin (1837) to Brown and Brown (1984) listed this species. In Hitchcock and Standley (1919) it appeared under the name *S. suaveolens* Schoepf.

16. *Solidago patula* Muhl.

This species was first noted in our literature by Shreve (1910). Tatnall (1946) listed it, but cited only a single specimen and that from Delaware. Frederick (Brown and Brown 1984) is an addition to the few counties cited in my paper (Kolb 1991).

17. *Solidago puberula* Nutt.

A specimen, apparently collected in Maryland by Vernon, is in the British Museum (Reveal et al. 1987a), but, as with *S. odora*, it existed under a polynomial and was not given a binomial until much later. The Maryland 19th century botanists also did not recognize it; possibly they did not distinguish it (and also *S. erecta*) from superficially similar species.

It was first mentioned in our literature by Hitchcock and Standley (1919) and listed by most authors since. Frederick, Allegany and Garrett (Brown and Brown 1984) are additions to my (Kolb 1991) list of counties. The same authors also listed var. *pulverulenta* (Nutt.) Chapm., which, however, I have not seen mentioned as occurring north of Virginia in any of the major floras of our region.

Solidago racemosa Greene

This binomial is used by Hitchcock and Standley (1919) and later authors for the entity listed below under *S. simplex.*

18. *Solidago rigida* L.

In the British Museum there is a specimen of this species obtained by one of the early colonial Maryland collectors (Reveal et al. 1987a). This is rather surprising, for in the past two centuries this species has been reported in the middle Atlantic states infrequently and in widely scattered places, mostly on the Piedmont Plateau and in the mountains. However, all the principal Maryland references, from Ward (1881) to the present, listed it. The following add to my (Kolb 1991) county records: Baltimore (Sollers 1888); Montgomery (Hitchcock and Standley 1919); Cecil (Tatnall 1946). None of these records is recent.

19. *Solidago roanensis* Porter

This species was first listed for Maryland by Shreve (1910) under the name *S. monticola* T. & G. Brown and Brown (1984) state, "Our plants belong mostly to the variety *monticola* (T. &. G.) Fern..." Gleason and Cronquist (1991) do not recognize this variety.

20. *Solidago rugosa* Mill.

Brown et al. (1987) listed a specimen from colonial Maryland in the Sloane herbarium in the British Museum.

Aikin (1837), Ward (1881) -- "A rough and a smooth form." -- and Sollers (1888) all listed this species under the name *S. altissima.* Shreve (1910) and all the principal subsequent authors used *rugosa.* Norton and Brown (1946) listed in addition *S. aspera* Ait. However, the epithet *asperais* is now used infraspecifically: as var. *aspera* (Ait.) in Hermann (1946) and Brown and Brown (1984). (Cronquist [1980] has *S. rugosa* ssp. *aspera* (Ait.) Cronq., but this combination has not yet appeared in the Maryland literature.) Further, there are var. *celtidifolia* (Small) Fern. (not recognized by Gleason and Cronquist 1991) attributed by Downs (1976) to Garrett County and var. *villosa* (Pursh) Fern. listed by Brown and Brown (1984).

21. *Solidago rupestris* Raf.

In the Maryland literature this species was first listed by Ward (1881) and by most Maryland authors since. However, Brown and Brown (1984) regarded it as var. *rupestris* (Raf.) Cronq. of *S. canadensis*. But Cronquist himself, in his last major work (Gleason and Cronquist 1991), still used the binomial. The listings by the Washington area botanists --if for Maryland -- must refer to counties other than Garrett (Kolb 1991), but none is definite.

22. *Solidago sempervirens* L.

Brown et al. (1987) in a discussion of Maryland colonial plant habitats "noting which species were discovered in each by the early naturalists (noted by an asterisk)..." then listed under "1. Beaches and Dunes" this species with an asterisk, but I have not been able to find in any of the several papers of which it is one (in Huntia 7, 1987) any other mention of it.

Aikin (1837) first listed this species, but under the name *S. laevigata* Ait. Ward (1881) omitted it, but all the other major references listed it as *S. sempervirens*. Hermann (1946) and Norton and Brown (1946) also listed var. *mexicana* (L.) Fern. Maryland is in the area in which the two varieties mingle; Linnaeus (1753) described them as distinct species.

Solidago serotina Ait.

This name occurs as follows in our literature: Sollers (1888) listed both *S. gigantea* and *S. serotina*; the latter is now considered to be a synonym of *S. gigantea* Ait. var. *leiophylla* Fern. Shreve (1910) listed *S. serotina* but not *S. gigantea*; since the pubescent-leaved variety is more abundant than the smooth-leaved, he was no doubt referring to what is now called *S. gigantea*. Hitchcock and Standley (1919) listed *S. serotina*, remarking, "(*S. gigantea* of Ward's flora.)" and also "*S. serotina gigantea* (Ait.) A. Gray", thus accounting for both varieties.

23. *Solidago simplex* HBK

This binomial does not occur in the Maryland literature as yet, but is accepted by Gleason and Cronquist (1991) as the proper one for an entity represented in Maryland by a single population at the Great Falls of the Potomac. This population first appeared in our literature in Ward (1881) under the name *S. virga-aurea* L. var. *humilis* Gray and is attributed to Virginia. Plants of this population do occur on the Virginia bank. However, most occur in the crevices of the rocks of the falls. Since the state line is the low watermark on the south side of the Potomac River, they are in Maryland. For these plants Hitchcock and Standley (1919) used the binomial *S. racemosa* as did later authors except Kolb (1991), who, following Cronquist (1980), used *S. spathulata* DC. (q.v., below). This Great Falls population is further designated as ssp. *randii* (Porter) Ringius var. *racemosa* (Greene) Ringius.

Solidago spathulata DC.

This binomial occurs in our literature in Kolb (1991) and Cronquist (1980). For the entity to which it refers, see above under *S. simplex*.

24. *Solidago speciosa* Nutt.

Sollers (1888) did not credit this species to the Baltimore region, listing it only on the authority of Ward (1881). All the other major references, except Hitchcock and Standley (1919), listed it. These references add to my list (Kolb 1991) the following counties: Garrett (Shreve 1910), Cecil (Tatnall 1946), and Howard and Montgomery (Brown and Brown 1984).

25. *Solidago squarrosa* Muhl.

Hermann (1946) listed this species with reference to Hermann (1941), the basis being a Virginia record. Tatnall (1946) listed it, but on the basis of a Delaware record. However, Fernald (1950) mentioned "Md." and Brown and Brown (1984) cited Allegany County, as did Kolb (1991).

26. *Solidago stricta* Ait.

When Ward (1881) and Sollers (1888) wrote, this name referred to what is listed below as *S. uliginosa* (q.v.). Although by the time of Shreve (1910) this was no longer the case, it seems that he, too, used *stricta* in that sense, for he stated, "Midland Zone", a remark that might well apply to *S. uliginosa* but could not refer to this Coastal Plain inhabitant, *S. stricta* Ait.

All the records of *S. stricta* Ait. in Tatnall (1946) refer to Delaware. Norton and Brown (1946) listed the name without comment. Brown and Brown (1984) stated, "Rare. Coastal Plain; Cecil and Prince Georges Counties..."

Solidago tenuifolia Pursh

This name, occurring in several Maryland references, is considered here to apply to a species in the genus *Euthamia.*

27. *Solidago tortifolia* Ell.

Tatnall (1946) explicitly restricted this species to Northhampton County, Virginia, "Here reaching its northern limit." Yet he listed in his bibliography Redmond (1932), who stated concerning Worcester County, Maryland, "Common near Maryland and Virginia Line."

28. *Solidago uliginosa* Nutt.

For Ward (1881), Sollers (1888), and Shreve (1910) see above under *S. stricta.* For Hitchcock and Standley (1919) and Norton and Brown (1946) see above under *S. neglecta.* Hermann (1946) and Tatnall (1946) used for this entity the name *Solidago uniligulata* (DC) Porter var. *neglecta* (T. & G.) Fern. There are no records for this species between Garrett County and the Baltimore-Washington area, where they are rather old, dating from the time before suburbia filled in bogs. Anne Arundel (Stieber 1971) is an addition to my (Kolb 1991) list of counties.

29. *Solidago ulmifolia* Muhl.

Aikin (1837) listed this species, but somehow Ward (1881), Sollers (1888) and Shreve (1910) missed it. However, all the later general lists have it. Garrett (Brown and Brown 1984) and Anne Arundel (Stieber 1971) are additions to my (Kolb 1991) list of counties.

Solidago uniligulata (DC) Porter

See *S. uliginosa* above.

Solidago virgata Michx.

See *S. stricta* and *S. uliginosa* above.

Solidago virgaurea L.

Some attempts were made in the 19th century to find a North American representative of this widespread Old World species. Sollers (1888) listed *Solidago virga-aurea* [sic!] L.var. *humilis* (Pursh) Gray; this is the entity listed above under *S. simplex.*

Summary

In this search of the Maryland *Solidago* literature 53 binomials have been found. These are applied to 29 species, as recognized -- except for the addition of *S. altissima* -- by Gleason and Cronquist (1991). The records of two of these --*S. stricta and S. tortifolia* -- I consider doubtful. The inclusion of the Gleason and Cronquist (1991) infraspecific entities brings the list of Maryland *Solidago* to 39 currently recognized taxa.

Acknowledgements

I should like to thank the library of the Maryland Historical Society for access to Aikin (1837) and the herbarium of the Towson State University for access to a facsimile copy of Linnaeus (1753)

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First Records of the Pygmy Shrew, *Sorex hoyi* (Insectivora: Soricidae), in Western Maryland and Pennsylvania

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Historically, *Sorex hoyi* Baird has been regarded as one of the rarest mammals in Maryland (Feldhamer et al. 1984). Until recently only two specimen records were known, both from on or near the coastal plain. Paradiso (1969) reported a single specimen taken at Berwyn, Prince Georges County. Subsequently Lee (1974) reported a second specimen collected on 15 July 1969 near Prettyboy Reservoir, Baltimore County. Diersing (1980) examined the Berwyn specimen as part of his revisionary analysis and referred it to *S. h. winnemana*; however, apparently unaware of the Baltimore County specimen, Diersing did not include it in his study.

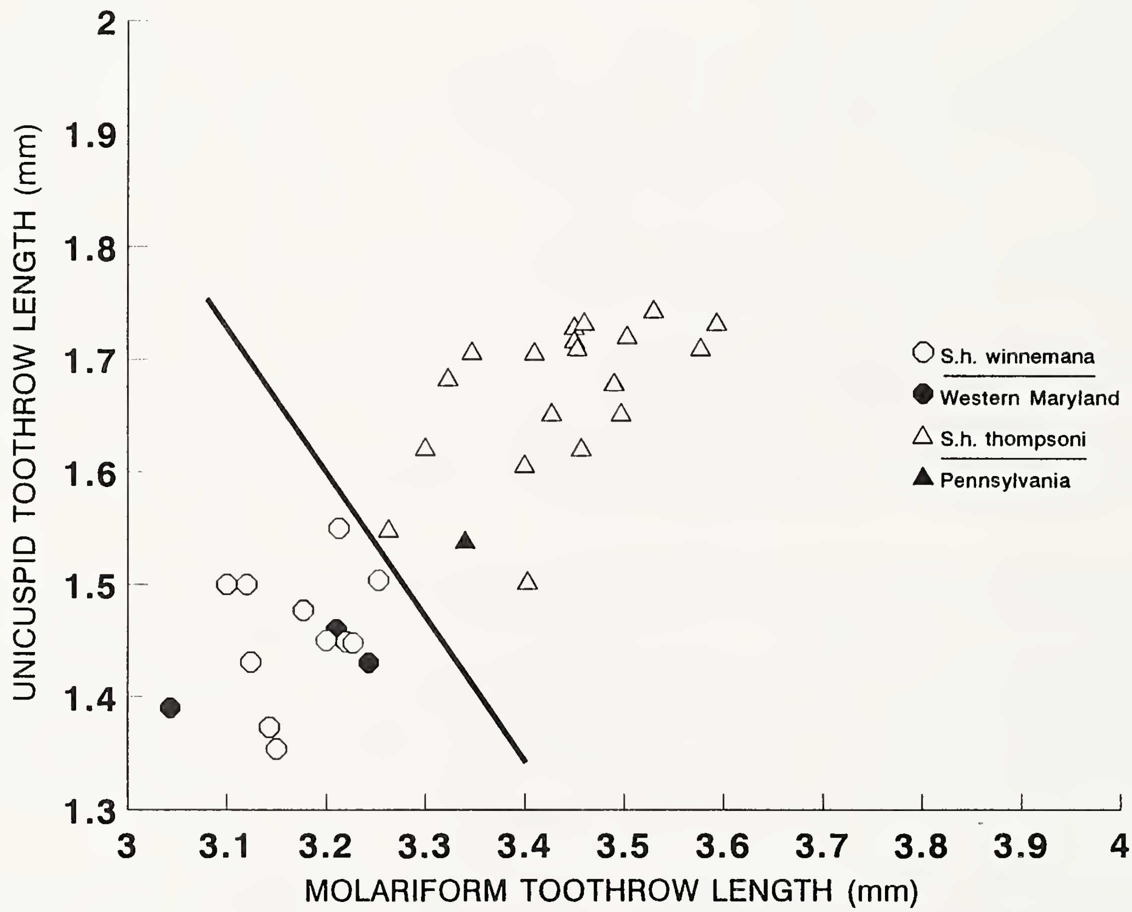
Subsequently, Kirkland et al. (1987) reported on the first records of *S. hoyi* from Pennsylvania, one specimen from Boalsburg, Center County, and two from east of Waynesboro, Franklin County. Since Pennsylvania represented a gap of some 200 miles in the distribution between *S. h. winnemana* (distributed to the south of Pennsylvania) and *S. h. thompsoni* (distributed to the north of Pennsylvania) Kirkland et al. (1987) compared the new Pennsylvania specimens as well as the two existing Maryland records to samples of *winnemana* and *thompsoni*. The results of their statistical analysis indicated that the Pennsylvania specimens should be referred to *S. h. thompsoni*. Of the two Maryland specimens, Kirkland et al. (1987) confirmed Diersing's (1980) analysis that the Berwyn specimen was referable to *winnemana*. However, Kirkland et al. referred the Prettyboy Reservoir specimen to *thompsoni*. More recently, Kirkland and Krim (1990) and Kirkland and Sheppard (in press) report on additional specimens obtained from Berks, Clearfield, Cumberland, Huntington and Westmorland Counties, Pennsylvania. Presumably these too would be referable to *thompsoni*.

In August, 1993, E. v. d. Berhge (Appalachian Environmental Research Center, Frostburg, MD) submitted to J. L. collections of shrews that were made by him in Garrett County in western Maryland as incidental captures in surveys for carabid beetles. Included in these collections were three specimens of *Sorex hoyi*. One specimen, a male (72-10-x), was taken on 18 July 1993 at Mt. Savage at an elevation of 914 m. Two additional specimens of indeterminate sex (69-29-9-x and 68-29-9-x) were taken on 31 July near Lanaconing on Mt. Savage, also at an elevation of 914 m. To our knowledge these are the first records of *Sorex hoyi* from western Maryland.

In addition to the Garrett County, Maryland records, there is a single specimen of *S. hoyi* included in collections made by E. v. d. Berhge in Fayette County, Pennsylvania. This specimen, also of indeterminate sex (72-28-10-x), was taken at Falling Water State Park at an elevation of 619 m. To our knowledge this is the first record of *S. hoyi* from western Pennsylvania. This site is approximately 40 air miles to the northwest of the Garrett County sites in Maryland. Both the Pennsylvania and Maryland specimens are reposited in the mammal collections of the University of Georgia Museum of Natural History, Athens.

We have examined the three Garret County, Maryland specimens and the Fayette County, Pennsylvania specimen utilizing the scattergrams of Diersing (1980) and Kirkland et al. (1987), which compare unicuspid toothrow length against molariform toothrow length (Figure 1). Results of this comparison indicate the three Maryland specimens to be comparable to the range of measurements of *winnemana* as reported by Kirkland et al. (1987), as shown in Table 1. However, the Fayette County, Pennsylvania specimen (Table 1) was comparable to the range of measurements of *thompsoni.*

Figure 1. Scattergram comparison of *S. hoyi winnemana* and *S. h. thompsoni* showing affinities of the three Garrett County, Maryland (closed circles) and Fayette County, Pennsylvania (closed triangle) specimens. Specimens below and to the left of the diagonal (circles) were referred to *winnemana* while those above and to the right (triangles) were referred to *thompsoni,* as plotted in Kirkland et al. (1987).



At the time of Diersing's (1980) revision and Handley et al. (1980) there were only 17 records of *S. h. winnemana* known in the region extending from southern Illinois east to Maryland and south throughout the Appalachian highlands to the Carolinas and Georgia. More recently, considerable information on the distribution, abundance and habitat associations of this

subspecies has become available from Indiana (Caldwell et al. 1982, Cudmore and Whitaker 1984), Virginia (Handley et al. 1980, Pagels 1987), Kentucky (Caldwell 1980, Caldwell and Bryan 1982), Tennessee (Kennedy et al. 1979, Kennedy and Harvey 1980, Tims et al. 1989, Harvey et al. 1992, Harvey et al. 1992, Feldhamer et al. 1993), North Carolina (Webster 1987, Laerm et al. in press), South Carolina (Mengak et al. 1987) and Georgia (Wharton 1968, Laerm, et al. 1994). This information indicates that the range of populations referred to *winnemana* is much more extensive that previously believed. Furthermore, it is also now known from a wider range of habitats and, while nowhere abundant, may be common where it occurs.

Table 1. Comparison of toothrow measurements of new *S. hoyi* specimens from Maryland and Pennsylvania compared to those of *thompsoni* and *winnemana* as reported by Kirkland et al. (1987).

Cranial measurement	*winnemana* (N=11)	*thompsoni* (N=15)	Maryland (N=3)	Pennsylvania (N=1)
Molariform toothrow length	3.17 (3.10-3.25)	3.46 (3.30-3.58)	3.16 (3.04-3.24)	3.34
Unicuspid toothrow length	1.45 (1.35-1.54)	1.67 (1.50-1.73)	1.43 (1.39-1.46)	1.54

The records of *S. h. thompsoni* from Pennsylvania reported by Kirkland et al. (1987), Kirkland and Krim (1990) and Kirkland and Sheppard (in press) indicate that the supposed distributional gap between *winnemana* and *thompsoni* suggested by specimens available to Diersing (1980) probably does not exist, at least not in Pennsylvania. This has been reinforced by G. Kirkland and M. Steele (personal communication) in northeastern Pennsylvania. We suggest that a reevaluation of the *winnemana-thompsoni* complex in the eastern United States, based upon the numerous new specimens available, may well indicate that pygmy shrews in this region represent a continuous cline of increasing size from south to north. If such is the case it is likely that the taxonomic distinction of *winnemana* would be questionable. Such a reevaluation is presently underway.

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The Livebearing Fish, *Gambusia holbrooki*, in Loch Raven Watershed Baltimore County, Maryland

Donnell E. Redman

During the late summer of 1992, while botanizing in a wetland adjacent to Phoenix Pond (just northwest of Phoenix, Baltimore County, Maryland) in the Loch Raven watershed, I noticed a small school of fish swimming near the shoreline. At first glance I assumed that the fish were *Fundulus diaphanus* (Lesueur), a locally common topminnow. However, their small size and short, darting movements led me to suspect that they could be mosquitofish of the genus *Gambusia* Poey.

On a subsequent trip I carried a minnow net and my fishing license (which allows a fisherman to legally collect minnows). The first cast of the net rewarded me with six small silvery fish which I identified as eastern mosquitofish (*Gambusia holbrooki* Woot., Scrib. and Smith.) (Figure 1).

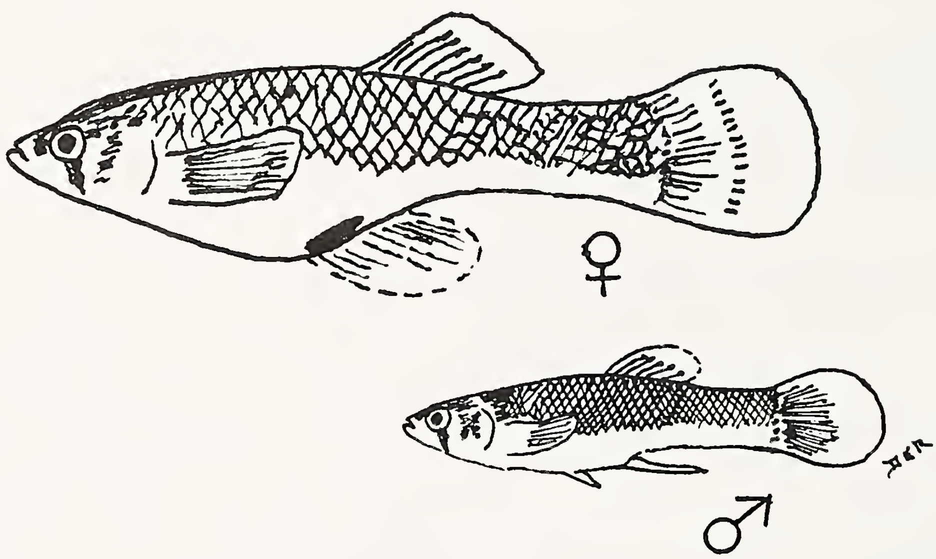

Figure 1. Female and male *Gambusia affinis* (x2) from Phoenix Pond, Baltimore County, Maryland.

The eastern mosquitofish belongs to the Family Poeciliidae, all of which give birth to live young. It is a small fish, with females reaching approximately 2 inches (5 cm) in length and males reaching 1 1/8 inch (2.9 cm). Their small size and silvery color gives them the appearance of a guppy (*Poecilia reticulata* Peters), but without the male guppy's body coloration. The eastern mosquitofish was previously classified as a subspecies (Rivas 1963) and subsequently as a semispecies (Black and Howell 1979) of *Gambusia affinis* (Baird & Girard), but it is currently considered a separate species (Wooten et al. 1988). *Gambusia affinis* is a western species that

ranges from Alabama throughout the Mississippi drainage, and southwest into Texas and eastern Mexico. *Gambusia holbrooki* is an eastern species whose range extends from central Alabama eastward into Florida and north along the Atlantic drainage into southern New Jersey. In Maryland *G. holbrooki* has been considered to be restricted to the Atlantic Coastal Plain and this report represents the first record of its occurrence on the Maryland Piedmont (Lee and Burgess 1980, Lee et al. 1981).

Subsequent investigations demonstrated that the eastern mosquitofish is present in Phoenix Pond, in nearby Green Branch, and along the edge of Loch Raven Reservoir adjacent to Paper Mill Marsh. However, I was unable to locate populations elsewhere in the watershed. It is probable that this species will spread throughout the Loch Raven watershed, wherever aquatic conditions are suitable.

Since *G. holbrooki* does not appear on the official reservoir species list and has not been previously taken in regular fish surveys conducted by the Maryland Department of Natural Resources (Gene Scarpulla, Superintendent of Reservoir Natural Resources Office, personal communication), this occurrence appears to represent a very recent introduction. These fish have been extensively stocked outside of their range for mosquito control (Courtenay and Stauffer 1984). They have also been widely released by tropical fish hobbyists and sports fisherman.

While discussing the eastern mosquitofish, Gene Scarpulla also informed me that he had seen "Koi" (Japanese colored ornamental pond carp, *Cyprinus carpio*) near the observation deck at the dam and that a large Oscar (*Astronatus ocellatus*) and a large Snakehead (*Ophicephalus*), both tropical aquarium fish, had been caught by fisherman in the reservoir. During a subsequent trip to the dam, I observed one Koi feeding on bread tossed into the water by visitors.

There is little doubt that the Koi, Oscar and Snakehead were released into Loch Raven by tropical fish hobbyists. However, the question of how mosquitofish became a part of the icthyofauna of Loch Raven Reservoir remains unresolved. My inquiries failed to locate anyone who knew anything about this introduction.

It is difficult to predict if this introduction will have any impact. Research (McClane 1978) has shown that in the south the mosquitofish provides forage for gamefish, such as the largemouth bass, *Mictropterus salmoides*. However, it may also impact some smaller native fishes and the young of larger species, including important game and food fishes (Courtenay and Stauffer 1984). Therefore, the situation should be monitored to determine if the introduction of *G. holbrooki* into the Loch Raven watershed impacts, either negatively or beneficially, the existing aquatic community.

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Survey for Calosoma Caterpillar Hunters (Coleoptera: Carabidae) in Maryland 1992-1993

C. L. Staines

Abstract

During 1992 and 1993, adult *Calosoma* beetles collected in blacklight traps were identified. Five species - *C. externum* (Say), *C. frigidum* Kirby, *C. sayi* Dejean, *C. scrutator* (Fab.), and *C. wilcoxi* LeConte - were collected in Maryland. Distributional and seasonal information are presented for each species.

Introduction

Beetles of the genus *Calosoma* (Coleoptera: Carabidae), "caterpillar hunters", feed on various caterpillars, grubs, and other immature insects. Both larvae and adults are predaceous. Adults are mainly nocturnal and some species are often found in large numbers at lights. When prey is abundant, beetles may be found running on the ground or climbing trees and shrubs in search of prey. During the day, adults are found under rocks and logs or in other secluded places. Doane and Schaefer (1971) found that *C. sycophanta* (L.) was a strong flier and, under certain conditions, would actively disperse during the day.

Calosoma larvae are active both day and night. Larvae eat the liquid and fatty portions of caterpillars or pupae and often do not completely consume their prey, thus killing more prey than is required for development.

Calosoma spp. are important predators in agroecosystems (Price and Shepard 1978) and forested areas (Burgess 1911, Weseloh 1985). Until recently, six species of *Calosoma* were known from Maryland: *C. calidum* (Fab.), *C. externum* (Say), *C. frigidum* Kirby, *C. sayi* Dejean, *C. scrutator* (Fab.), and *C. wilcoxi* LeConte (Bousquet and Larochelle 1993). In 1984, an adult *C. sycophanta* was found dead on 23 July at Northeast in Cecil County, Maryland (P. Schaefer, personal communication). This European predator was intentionally introduced into Massachusetts in 1907 for use against the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae) (Burgess 1911).

Methods

Adult *Calosoma* beetles were collected from the Maryland Cooperative Blacklight Trap Survey Program in 1992 and 1993. The Maryland Blacklight Trap Survey maintains 58 blacklight traps in 22 counties (all except Allegany County). Traps were placed in various agricultural cropping situations to monitor pest populations. Trap catches were submitted at least weekly from late March to early October.

Beetles were identified using keys provided by Gidaspow (1959). Since many of the characters used in identification are small, and many specimens were covered with moth scales,

the beetles were cleaned by soaking in alcohol. Specimens were then mounted and labeled. Voucher specimens have been deposited in the Maryland Department of Agriculture Collection (Annapolis, MD).

Results

A total of 1133 *Calosoma* specimens was collected (717 in 1992, 416 in 1993). Five of the seven species previously reported from Maryland were collected.

Calosoma sayi was the most commonly collected species, accounting for 643 specimens (89.6%) in 1992, and 308 specimens (74.0%) in 1993. Specimens were found in 17 of the 22 counties surveyed (Map 1). Adults were collected from 22 May to 17 September.

Young (1985) states that *C. sayi* is an important predator in agroecosystems in the southeastern United States, which may explain its abundance in this survey. Young (1984) found that *C. sayi* fed on a wide variety of living and dead insects.

Calosoma scrutator was the second most commonly collected species with 64 specimens (8.9%) in 1992 and 73 specimens (17.5%) in 1993. Adults were collected in 15 of the 22 counties (Map 2) between 11 May and 26 September.

Burgess and Collins (1917) report that *C. scrutator* is a nocturnal predator of lepidopterous larvae. Most work on this species has been done in relation to gypsy moth predation.

Calosoma wilcoxi was collected nine times (1.2%) in 1992 and 15 times (3.6%) in 1993. Adults were collected in 11 counties (Map 3) from 2 May to 25 June.

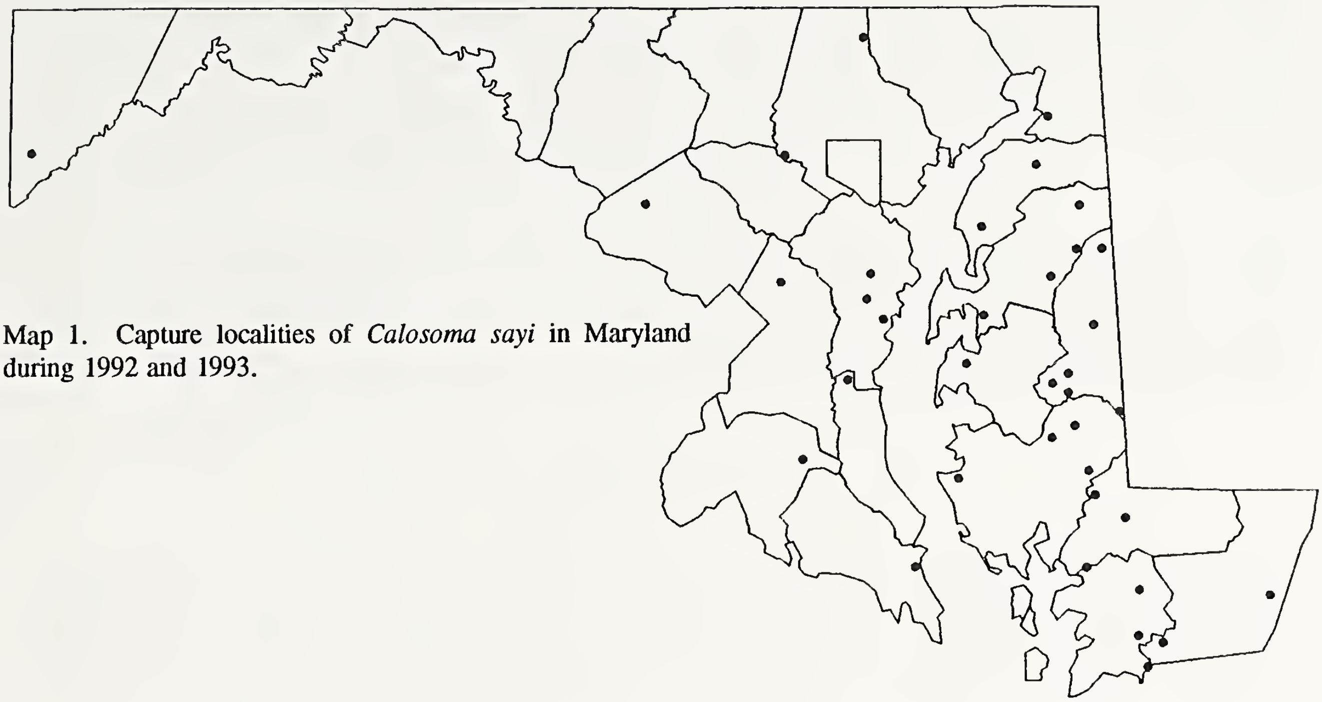
There is little published information available on *C. wilcoxi*. Burgess and Collins (1917) reported that it fed on lepidopterous larvae and that adults were only active in the spring.

Calasoma externum was not collected in 1992. However, four specimens of *C. externum* were collected in 1993 as follows: one each on 25 May, 17 July, 19 July, and 12 August in four counties (Map 4). Burgess and Collins (1917) found that this species would climb trees if forced but never climbed on its own. These beetles feed on a wide variety of insects (Orthoptera, Lepidoptera, and Coleoptera).

One specimen of *C. frigidum* was collected on 20 July 1992 in Somerset County (Map 4) but none was collected in 1993. Burgess and Collins (1917) found this species to feed on lepidopterous larvae and to be arboreal.

Discussion

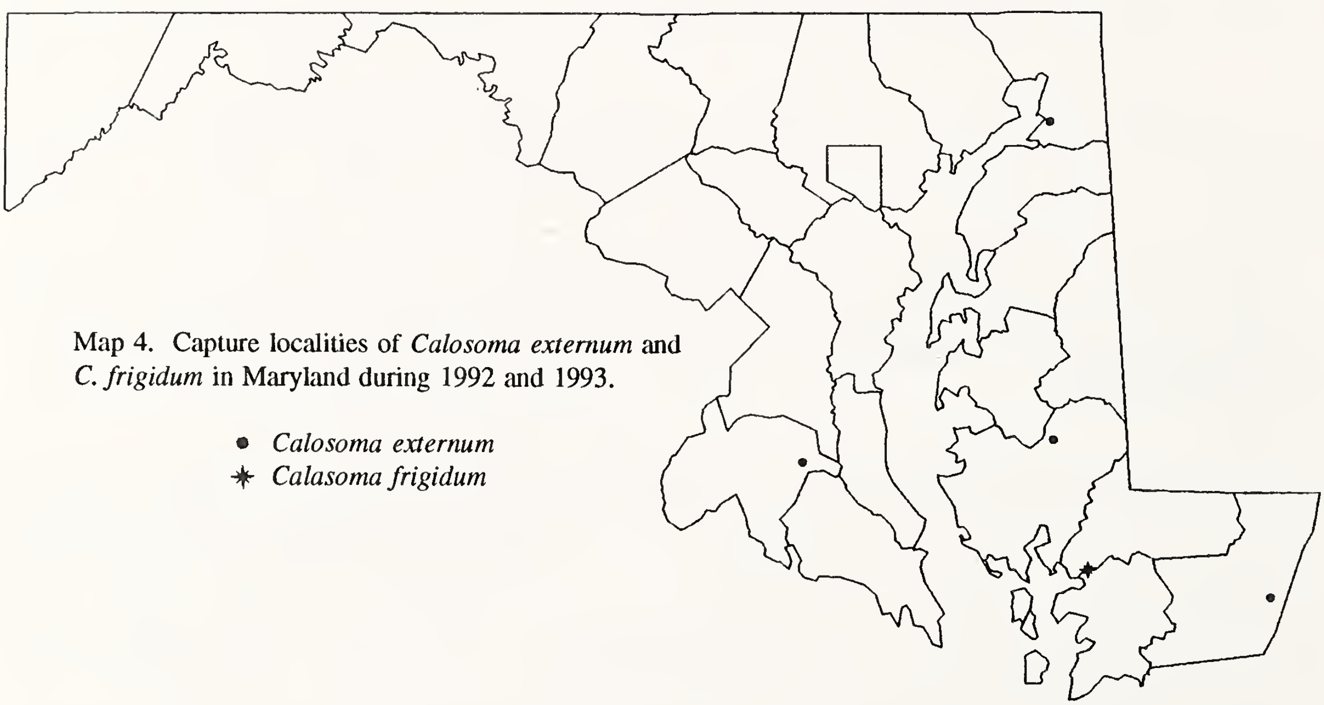
There is no published distributional information on *Calosoma* spp. in Maryland. The only historical reference is Ulke (1902), who records five species in the Washington, DC area but gives no ecological, distributional or abundance information.



Map 1. Capture localities of *Calosoma sayi* in Maryland during 1992 and 1993.

Map 2. Capture localities of *Calosoma scrutator* in Maryland during 1992 and 1993.

Map 3. Capture localities of *Calosoma wilcoxi* in Maryland during 1992 and 1993.



Map 4. Capture localities of *Calosoma externum* and *C. frigidum* in Maryland during 1992 and 1993.

Basing the survey exclusively on blacklight traps may not give a true indication of the relative abundance of the various species. Burgess (1911) states that *C. scrutator* is highly attracted to lights while *C. frigidum* is only occasionally collected at lights and *C. sycophanta* was never collected at lights. Burgess and Collins (1917) state that *C. externum, C. sayi*, and *C. wilcoxi* are all attracted to lights but they make no mention of *C. calidum* being attracted to lights. This may explain why *C. calidum* and *C. sycophanta* were not collected during this survey and why only one *C. frigidum* was collected.

The other bias of this survey was that all of the blacklight traps were placed in or on the edge of agricultural fields. No effort was made to survey wooded areas, which are the preferred habitat of *C. frigidum* and *C. sycophanta*. However, some traps were near enough to woods that they would attract the species that do come to blacklight traps.

Acknowledgements

I thank D. Crouch, A. M. Jones, and R. A. Bean for collecting the beetles from the blacklight samples. S. L. Styczynski assisted in the preparation and labelling of the material. W. F. Gimpel, Maryland Department of Agriculture, and P. W. Schaefer, USDA, Beneficial Insects Introduction Research, commented on earlier drafts of this manuscript. Maryland Department of Agriculture Contribution Number CN 84-94.

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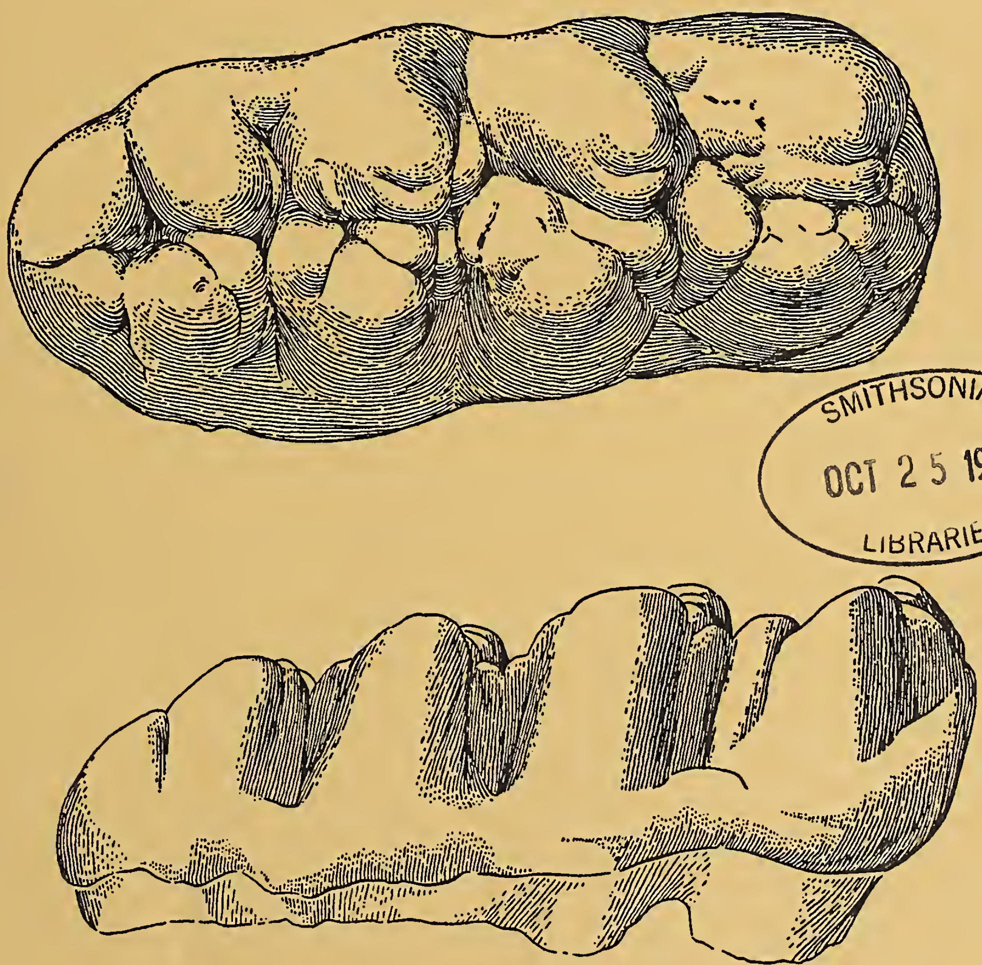

Volume 38, Number 3-4 July/Dec. 1994

ISSN 0096-4158

The Maryland Naturalist

Volume 38, Number 3-4 July/Dec. 1994

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: September 14, 1995

Cover Illustration: Drawing of right molar tooth of Miocene elephant, *Gomptotherium calvertensis*. Although very rare, several teeth from this elephant have been found along the Chesapeake Bay at Calvert Cliffs, and another was found near Greensboro in Caroline County. This particular specimen, collected near Governor Run by A. Hecklinger in 1931, is known only from a plaster cast. The original was in the collection of the Maryland Academy of Sciences, but has since been lost. However, it may still exist, perhaps in some unknown private collection.

Noteworthy Mammal Records from Northern Virginia

Carl H. Ernst

Two unrecorded specimens from northern Virginia in the mammal collection of the Department of Biology, George Mason University (GMU) are of sufficient interest to report.

The first of these is a full albino, adult, short-tailed shrew, *Blarina brevicauda kirtlandi* (GMU 1265, alcoholic specimen; TBL 98 mm, TL 21 mm, HF 12 mm), found D.O.R. at the junction of Fort Hunt and Plymouth Roads, Fairfax County, Virginia on 14 September 1985 by Jeffrey E. Lovich. Albino shrews are rare. Jackson (1928) recorded only three albinos in a series of over 10,000 individuals of the genus *Sorex*, and Hamilton (1939) found only two in a series of several thousand *Blarina*. Records of only nine albino *Blarina brevicauda* from scattered states have been previously published: Delaware (Ulmer 1940b), Indiana (Murray 1939), New York (3; Hamilton 1939, Shapiro 1950), Ohio (Svendson and Svendson 1975), Pennsylvania (2, one full and one partial; Ulmer 1940a), and Vermont (Williams 1962). Only the specimen from Smyrna, Kent County, Delaware (Ulmer 1940b) and that from northern Virginia are from south of the Mason-Dixon Line, and the Virginia specimen is the first albino individual recorded from south of the Potomac River.

The second interesting specimen is an adult female fox squirrel, *Sciurus niger vulpinus* (GMU 12, skin only, TBL 550 mm, TL 240 mm, HF 65 mm) found D.O.R. at the Roberts Road entrance to George Mason University, Fairfax, Fairfax County, Virginia by Nicholas Konchuba on 20 October 1973. Unfortunately the skull was too badly crushed to preserve, but its maxillary tooth row contained only four cheek teeth, lacking the small peg-like premolar found in the grey squirrel, *S. carolinensis*, the only other squirrel in the area with which *S. niger* could be confused. Also, the large size and color pattern show it to be a fox squirrel. Although northern Virginia is in the historic range of *Sciurus niger* (Burt and Grossenheider 1976, Hall 1981), the species is extremely rare at best in the area encompassed by Alexandria and Arlington, Fairfax and Prince William counties. Other than GMU 12, *S. niger* has only been collected in Fairfax County three other times, and not since 1932: United States National Museum of Natural History, Smithsonian Institution (USNM) 101581-101584, a male and three females, taken at Accotink, 8 January, 1900, by G. Sheppard; USNM 143970, a male, collected at Bloomgrove, 22 December, 1906, by W. L. Ralph; and USNM 288061, sex undetermined, collected at Great Falls, 10 September, 1932, by C. H. M. Barrett. GMU 12 appears to be the last recorded from the region, as none have been seen in Fairfax or its immediate vicinity since the early 1970s. Fox squirrels are still fairly common farther west in the sparsely developed parts of Clarke, Fauquier and Loudoun counties (pers. obs.), but *Sciurus niger*, and its relative the northern red squirrel, *Tamiasciurus hudsonicus*, have virtually disappeared from developed portions of northern Virginia in the past 20 years.

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An Additional Record of the Freshwater Jellyfish, *Craspedacusta sowerbyi*, on Maryland's Eastern Shore, with Notes on its Habitat (Hydrozoa: Hydroida: Petasidae)

David G. Jenkins, William L. Grogan, Jr., and Michael E. Folkoff

Allan (1952) apparently provided the first record of *Craspedacusta sowerbyi* Lankester (sic as *C. sowerbii*) from Maryland when he reported specimens in the Potomac River at Plummers Island (Montgomery County) located in the Eastern Division of the Piedmont. More recently, Rivers (1987) reported *C. sowerbyi* from ponds in Montgomery County and from the Ridge and Valley section of the Appalachian Province (Washington County). Grogan (1990) reported *C. sowerbyi* from the Outer Coastal Plain (Eastern Shore) in Dorchester County and Turek (1992) reported this species (as *C. sowerbi*) from the Inner Coastal Plain (Western Shore) in Anne Arundel County. Finally, Bagley (1993) reported this species from a Baltimore County quarry, in the Eastern Division of the Piedmont. We provide a second record of this species from the Eastern Shore of Maryland and present data on its habitat.

Medusae of *C. sowerbyi* were observed during field studies at East Lake in Wicomico County, Maryland between August and October 1991. Voucher specimens were preserved in a buffered 5% formalin solution and deposited in the invertebrate collection at Salisbury State University. Although medusae were not quantitatively sampled, densities were estimated while snorkeling, and appeared highest in August (up to approximately 20 m^{-3}), when they were localized within the pond. Medusae were typically distributed within the upper 2 m of the water column during daylight hours. Highest densities occurred in areas with greatest depth; none were ever observed in near-shore areas. Bagley (1993) observed a similar spatial distribution in a Baltimore County quarry, in that the majority of medusae were concentrated along a submerged cliff face in the NW corner of the quarry at 2 ft (0.6 m) below the surface. It is noteworthy that *C. sowerbyi* medusae were present in the water column for a three month period (Aug.-Oct.). The paucity of observations on *C. sowerbyi* in Maryland, and the reputation of medusae as ephemeral or occurring sporadically within the state, may be partially related to the relative infrequency of detailed observations by interested scientists or difficulties in measurement (Dodson and Cooper 1983). For example, Bagley (1993) indicated that medusae of *C. sowerbyi* occur annually in a Baltimore County quarry. Acker and Muscat (1976), provided detailed data on the ecology of this species (sic as *C. sowerbii)* and records for most of the United States. Nevertheless, they apparently overlooked the earliest record of *C. sowerbyi* from Maryland (Allan 1952).

East Lake (Fig. 1) is located SE of Salisbury just S of Johnson Road and W of its intersection with the Rt.13 bypass. This site was excavated in the early 1970's as a borrow pit during construction of the adjacent Rt. 13 bypass and subsequently filled with groundwater, thus producing the pond. Development of the shoreline began in the late 1970's, and continues at present except for the SE shoreline bordering the Rt. 13 bypass. The pond has no permanent surface inflow, but is fed mainly by groundwater discharge. We measured groundwater discharge with flux meters at the sediment-water interface at rates up to 3.0 L m^{-2} hr^{-1}, and rates up to 100 mL hr^{-1} using mini-piezometers. It receives minor surface runoff from heavy precipitation events and occasional overflow from an adjacent drainage ditch.

East Lake has a surface area of 9.5 ha, mean depth of 2.5 m (8.2 ft) and maximum depth of 4 m (13 ft). It is slightly mesotrophic, with circumneutral pH and soft water, which are consistent with other observations (Acker and Muscat 1976). Previous studies have reported only temperatures and dissolved CO_2, however, we measured winter nutrient levels of 3.0 mg l^{-1} NO_3+NO_2, and 0.01 mg l^{-1} total P. These low nutrient levels are consistent with oligotrophic conditions, but winter levels represent the highest levels of nutrients available during the year, suggesting that *C. sowerbyi* can thrive under low nutrient levels.

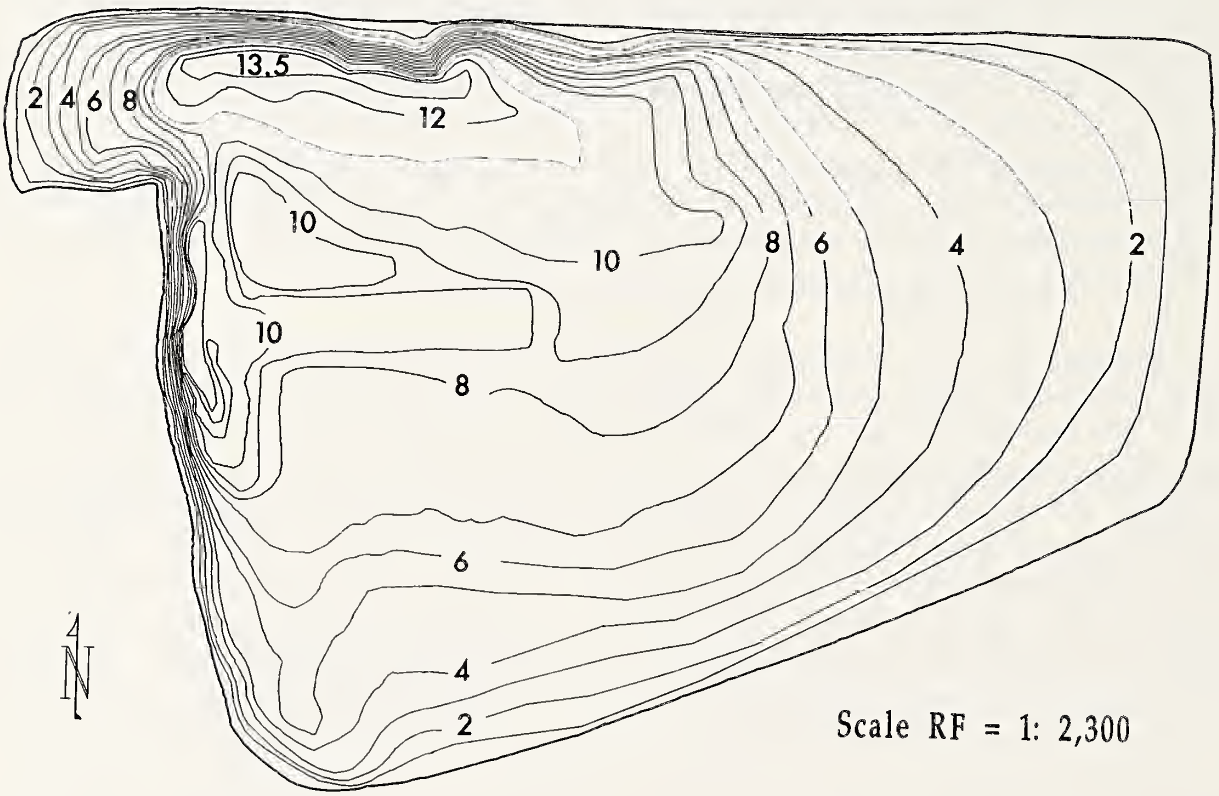

Figure 1. Bathymetric map of East Lake, Salisbury, Wicomico County, Maryland. Depths shown in 1 foot (0.3 m) intervals.

The pond's substrate is composed of fine to very fine sands and is generally sparsely vegetated. The bottom is gently sloping, with the exception of three excavated trenches; one extends along the west edge of the pond, another along the north edge, and a broader trench extends from the west edge to roughly the middle of the pond (Fig. 1). These trenches are steep sided, roughly 5 m wide, and slope gradually along their longest axes from their maximum depths to the adjacent shallows. We observed *C. sowerbyi* in the general area of the intersection of the west and north trenches in which the exotic macrophyte *Hydrilla* exists in high densities. We recorded densities of 1700-2200 *Hydrilla* stems m^{-2} in the west trench and 700-900 stems m^{-2} in the north trench. *Najas* was also present in the trenches, but in far lower densities. Polyps of *C. sowerbyi* are usually found on rocks, old wood or vegetation (Acker and Muscat 1976). Because solid objects are absent in East Lake and its substrate is unstable, polyps must develop exclusively on submerged vegetation in this pond.

The literature suggests that *C. sowerbyi* has relatively broad environmental requirements, in that medusae have been reported from a variety of freshwater habitats throughout the United States (Pennak 1978). Our study is consistent with the common observation of *C. sowerbyi* medusae in relatively young impoundments (quarries, borrow pits, ponds, etc.) (Acker and Muscat 1976), which may indicate their preference for relatively clear waters (low nutrients, near neutral pH) and/or relatively high groundwater discharge rates. Medusae have been shown to be ecologically important predators of zooplankton, especially the rotifer *Asplanchia* (Dodson and Cooper 1983). Colonial hydroids may also be important predators of microinvertebrates and protists in the littoral zone of many freshwater systems, but little is known on this subject. Finally, synchronous production of medusae by asexual polyps may serve as an interesting system for testing ecological and evolutionary hypotheses.

Acknowledgements

We thank the following students for their assistance with various projects in East Lake related to this paper: Alex Brence, Clayton Crown, Howard French, Sean Mullarkey, and Bruce Wilson. We gratefully acknowledge financial support from the Richard A. Henson School of Science and Technology. We also thank the East Lake Homeowners Association and especially Kent Kimmel, for access to East Lake.

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Solidago (Asteraceae) in Maryland III: Mixed Populations of *S. bicolor* and *S. hispida*

Haven Kolb

Abstract: A study of garden-grown offspring from individuals in a mixed population of *Solidago bicolor* L. and *S. hispida* Muhl. indicated that the ray color of offspring is not determined by the ray color of the pistillate parent.

Introduction

Until *Aster ptarmicoides* (Nees) Torrey and Gray was recently transferred to *Solidago*, the only goldenrod with white rather than yellow ray florets was *S. bicolor* Linnaeus. A plant very similar to *S. bicolor*, except principally, in having the usual yellow ray florets of goldenrods was named *Solidago hispida* by Muhlenberg. Later Torrey and Gray (1841) regarded this entity as merely a variety of *S. bicolor* and during the middle decades on the nineteenth century it was commonly listed as *S. bicolor* var. *concolor* T. & G. (e.g. Gray 1889). However, by the end of the century opinion had reverted to Muhlenberg's name (e.g. Robinson and Fernald 1907). Nevertheless, as late as 1910 "The Plant Life of Maryland" used the Torrey and Gray epithet (Shreve 1910), but at the specific rather than the infraspecific level! The nomenclatural shifts reflect indecisiveness concerning the taxonomic status of these plants.

Descriptions of *S. bicolor* and *S. hispida* in manuals differ only slightly and the character states described greatly overlap except in characters of the heads. Torrey and Gray (1841) remarked, "We can in no way distinguish the *S. hirsuta* Nutt. [a later synonym of *S. hispida* Muhl.] from *S. bicolor* except by the color of the rays in which the latter differs from the rest of the genus..."

Later, other writers added a character of the phyllaries (involucral bracts). For example, in the first edition of Britton and Brown (1898 the description of *S. bicolor* ends, "...rays white; achenes glabrous." The description in the second edition (Britton and Brown 1913) is identical except that it inserts between these last two phrases "...bracts of the involucre whitish, obtuse, the midvein broadened above;..." Likewise the description of *S. hispida* is the same in the two editions except that the second edition inserts, "...involucral bracts yellowish, obtuse, the midvein narrow..." In all the recent manuals I have examined, this involucral distinction appears with somewhat varying wording. In herbarium specimens this phyllary character is more enduring than the ray character. However, in my own study, I have not always been able to discern correlation of the two characters even in fresh material.

A Problem Population

In the middle Atlantic states of Pennsylvania (Rhodes and Klein 1993), Maryland (Kolb 1991), Delaware (Tatnall 1946), and Virginia (Harvill et al. 1986) *S. bicolor* is quite generally distributed, but *S. hispida* is less frequently encountered and then predominantly in the Piedmont Plateau and mountain regions.

In the early 1980's I found a small population of *S. hispida* growing on a steep road cut in the Piedmont of northern Baltimore County, Maryland. The site had been created by the reduction of a curve in the road only about ten years previously and bore a vegetation of scattered weedy plants as well as patches of lichen-covered or even quite bare soil. Among the vascular plants were many *S. bicolor* and a smaller number of *S. hispida*. The former is a fairly common plant in the surrounding area but the nearest known station of *S. hispida* is about 40 km away. The ratio of individuals of the two was about 10 *S. bicolor* to 1 *S. hispida* and this has been maintained for more than a decade.

Garden Observations

The existence of this small, isolated population of *S. hispida* in the midst of the common, generally distributed *S. bicolor* in combination with the history of vacillation in the taxonomic status of the two entities interested me. The question arose: Do the two supposed species retain the ray color difference in their offspring?

In 1990 I marked a number of the white-rayed individuals in the roadbank population while they were in fresh flower and later harvested seeds from them. The next spring I raised seedlings from this harvest and then planted them in my garden. Of these, 25 reached flowering stage, in which I could record the color of the rays. In 1992 I marked several yellow-rayed individuals in the roadbank population and followed the same procedure, obtaining 33 flowering progeny.

The results from these two trials are summarized as follows:

	White-rayed Parent	Yellow-rayed Parent
White rayed Offspring	23 (92%)	24 (73%)
Yellow-rayed Offspring	2 (8%)	9 (27%)

Discussion

Hybridization is frequent in the genus *Solidago*. Fernald (1950) mentions hybridization of *S. bicolor* and *S. hispida* as does Cronquist (1980), who adds "...but [*S. bicolor*] retains its populational identity over large areas." I am not clear as to what this remark means. However, it can be said that at my study site for well over a decade both *S. bicolor* and *S. hispida* have maintained some kind of populational identity, i.e. a rough ratio of 10:1 individuals with respect to ray color. Yet the results of my study seem to indicate that the line of descent of these individuals in any one generation does not necessarily include only individuals of like ray color in the previous generation.

Nevertheless, it must be pointed out that only the pistillate parentage is known in this study. Furthermore, a few individuals scored in my results as white-rayed were slightly cream colored and 3 of the yellow-rayed plants are listed in my notes as "pale yellow." Torrey and Gray (1841) wrote, "...these [the rays], however are not pure white in *S. bicolor*, but cream-color..." I have casually noted slight variation in the degree of whiteness in the ray florets of fresh *S. bicolor* from other Maryland populations, but I do not have notes of pale yellow rays in wild *S. hispida*.

The total offspring numbers in this study are too small to serve as a basis for general statements, but the striking departure from the parental ray character by some of the offspring in the direction of the ray character state of the other entity certainly suggests some weakening of specific status. It would be desirable to have other offspring investigations involving larger numbers and carried out in other places where *S. bicolor* and *S. hispida* coexist.

Acknowledgments

I wish to thank Dr. Arthur O. Tucker and Dr. Leonard J. Uttal for answers to some specific questions that arose in the course of this investigation. An anonymous reviewer provided several valuable corrections and improvements in the typescript.

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The Rediscovery of the Stripeback Darter, *Percina notogramma* (Raney and Hubbs), in Maryland[1]

Stephen P. McIninch, Richard L. Raesly
and Roman V. Jesien

Introduction

The stripeback darter was originally described by Charles Girard in 1859 from an Anne Arundel County, Maryland locality reported as an eastern tributary of the Potomac River (Collette and Knapp 1967). The stream is more likely a tributary of the Patuxent River, which drains most of the county. The original name, *Hadropterus maculatus*, was preoccupied by the blackside darter; thus Raney and Hubbs (1948) renamed the species *Hadropterus notogrammus*, giving a full description of the stripeback darter using specimens from Maryland and Virginia. They examined 25 specimens from Maryland, 11 from the Potomac River drainage and 14 from the Patuxent River drainage. The most advanced date for Maryland specimens was 1944. Hogarth and Woolcott (1966) recognized two subspecies, *Percina notogramma montuosa* from the upper and middle James River drainage and *P. n. notogramma* covering the remainder of the range. Maryland specimens examined by Hogarth and Woolcott (1966) were all collected in 1944 or earlier.

The results of surveys in the Potomac and Patuxent River drainages since 1944 revealed no stripeback darters (Dietemann and Giraldi 1973; Dietemann 1974, 1975; Norden and Norden 1979; Norden 1982; Lebo 1983; Cummins 1989; McIninch et al. 1992). Lee et al. (1984) suggested that the stripeback darter was extirpated from the state. The Maryland Department of Natural Resources reported the status of the species as endangered extirpated. We report the rediscovery of the stripeback darter, *Percina notogramma*, in Prince Georges County, Maryland, and review aspects of the distribution and life history of the species.

Distribution and Habitat

The stripeback darter is endemic to the Atlantic slope from the Chesapeake Bay drainages of the James River in Virginia and West Virginia, north to the Patuxent River of Maryland. As late as the mid 1980's *P. notogramma* was thought to be common in Virginia (Lee et al. 1984). The species is currently considered uncommon in most of Virginia (Jenkins and Burkhead 1994), rare in the Virginia tributaries of the Potomac River, and until now extirpated in Maryland.

The preferred habitat of *P. notogramma* is warm, usually clear streams and rivers of moderate gradient. The species inhabits areas with clean or silted substrates of sand, gravel, rubble or boulders. They are commonly taken in areas of slower currents including pools and slow runs but also inhabit swift riffles (Raney and Hubbs 1948, Jenkins and Burkhead 1994).

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[1]UMCEES Contribution No. 2698

Biology

Flemer and Woolcott (1966) examined the gut contents of four specimens of *P. notogramma* and found stonefly larva in three specimens. Other macroinvertebrates are probably also eaten.

Stripeback darters live up to three years and may not become mature until they are over a year old (Jenkins and Burkhead 1994). Spawning probably takes place in early to late spring in gravel riffles (Loos and Woolcott 1969, Jenkins and Burkhead 1994). Loos and Woolcott (1969) observed stripeback darters burying eggs in aquaria but observations have not been made in the wild. This species often occurs with a related darter, *Percina peltata* (shield darter), which is similar in appearance and with which it hybridizes naturally (Loos and Woolcott 1969).

Rediscovery

On 18 July 1995 six adult stripeback darters were collected by S.P. McIninch from Collington Branch, a tributary of the Patuxent River, 1.85 km N of the intersection of Rts. 725 and 202 in Upper Marlboro, Maryland. This is the first reported collection of the species from Collington Branch and the first report of the species from the state since 1944. The specimens were taken from a partly silted, one meter deep pool close to a shallow riffle about 10 meters in length and average depth approximately 20 cm. This is consistent with the habitat of the species in Virginia (Jenkins and Burkhead 1994).

Another collection of *P. notogramma* was made by R.L. Raesly from Cabin Branch 2.3 km NW of Upper Marlboro, Maryland, on 26 July 1995. Two specimens were captured from a small sand-bottomed run just below the confluence of Cabin Branch and Back Branch. The darters occupied a position along an undercut bank in approximately 30 cm of water. Cabin Branch is a tributary of Western Branch, which enters the Patuxent River near Mt. Calvert, Maryland.

Voucher specimens from the rediscovery sites are housed at the Frostburg State University Ichthyological Museum (Cabin Branch, catalog no. UMS-FSU 9546) and the private collection of the first author (Catalog no. 894).

Summary

The historic collection localities of stripeback darter in Maryland include several localities in the Anacostia River system, and others of the upper Patuxent River system around Laurel, Maryland. These waters have been dramatically urbanized since the early 1940's. The lack of subsequent collections of stripeback darter and the degradation of these watersheds suggested extirpation from the state as early as the late 1970's (Lee 1980). The serendipitous occurrence of two researchers independently rediscovering, within two weeks of each other, a species that had not been observed in over fifty years is, indeed, interesting. The low numbers and scarcity of sightings of this species in the state are enigmatic as there appears to be ample substrate type and habitat for the species' existence. Further survey work may uncover other populations of the species in Maryland.

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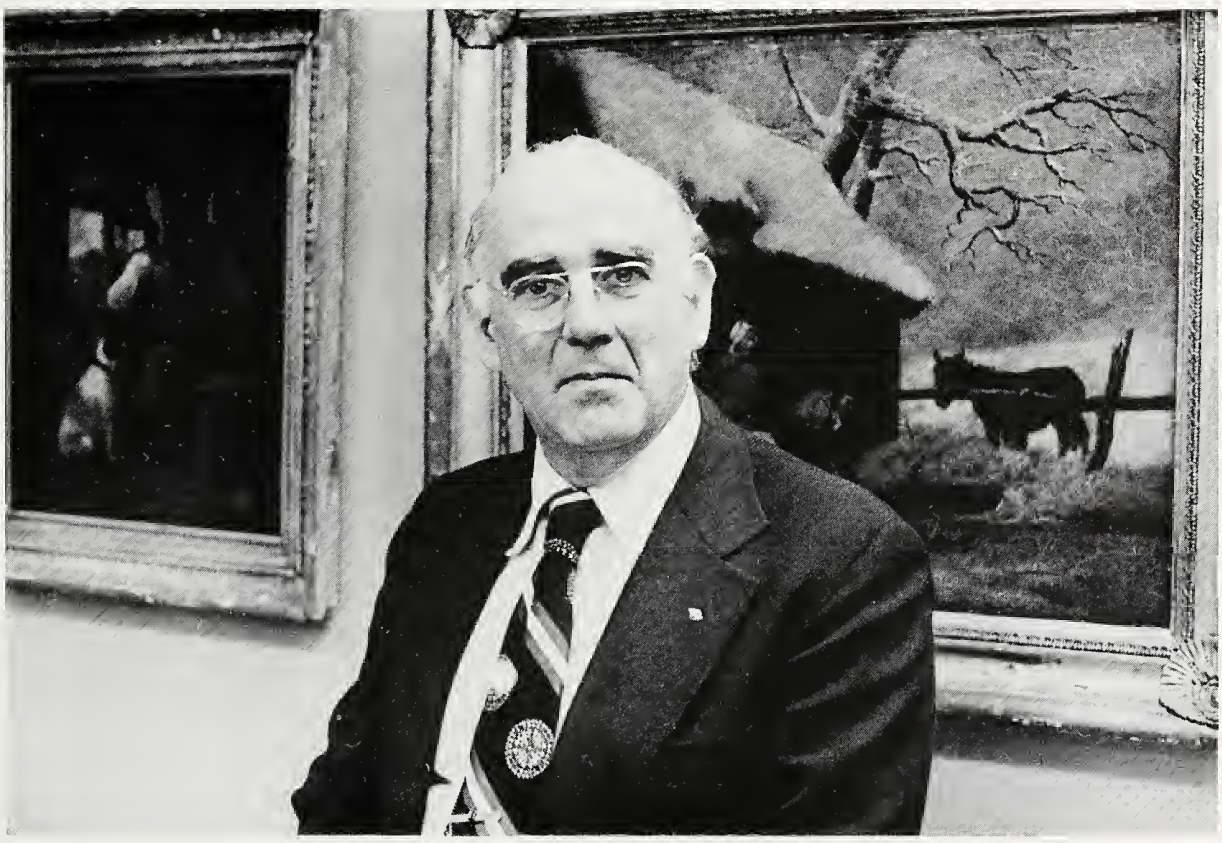
In Memoriam, Dr. Wilfred B. Hathaway

Donald W. Windler and
Donnell E. Redman

Doctor Wilfred B. Hathaway, long time member of the Natural History Society of Maryland, died September 15, 1994 at Fallston General Hospital.

Doctor Hathaway, 74, was retired Dean and Director of Graduate Studies at Towson State University and President Emeritus of the Natural History Society of Maryland. He received his baccalaureate from Massachusetts State College in 1941, his master's degree from the University of Massachusetts in 1947, and a doctoral degree from Cornell University in 1950.



Doctor Wilfred B. Hathaway ca. 1980, then serving as Dean of Graduate Studies at Towson State University. Photograph provided by Towson State University, University Relations.

Doctor Hathaway was an active member of the Natural History Society of Maryland from 1956 until his death in 1995. During that period he served the society in numerous ways. He

was Curator of the Department of Entomology, taught summer nature school in 1960, and gave several six week workshops in invertebrate zoology in 1962 and 1963. He was elected as a Corporate Member in 1957 and became a member of the Board of Trustees two years later. He also served as vice president from 1959 to 1960, and subsequently as president from 1963 to 1968. While Dr. Hathaway was president the NHSM acquired its present headquarters building on North Charles Street and moved from the previous headquarters on Bolton Street. That this was accomplished smoothly is a tribute to Dr. Hathaway's administrative ability.

Doctor Hathaway was a biology professor for 30 years at Towson State University, and Chairman of the Department of Science for 5 years. As early as November, 1957 he participated in committee meetings to initiate graduate studies at what was then Towson State College. These meetings led to Towson's first master's degree program, the Master's of Education in Elementary Education, in 1958. In 1967 Dr. Hathaway was appointed Director of Graduate Studies. In the Fall semester, 1970 he was named Dean and Director of Graduate Studies, a title he held through Towson's move to University status in 1976 and until he retired in 1979. Under Dr. Hathaway's direction graduate studies grew from six master of education programs in 1976 to thirteen programs, including Master of Arts and Master of Science degrees, by the time of his retirement. In 1986 the Biology Department established the annual "Wilfred Hathaway Award" that may be given to an outstanding graduate student in biology. The award has been presented 8 times since 1986. Doctor Hathaway was also affiliated with the University of Baltimore and Harford Community College.

His interests were many and varied. Dr. Hathaway was a talented musician who played the organ and piano, and was supervisor of music for the public schools of Amhurst, Massachusetts in the 1940s. In his home in Churchville, Dr. Hathaway maintained a special music room which housed his beloved pipe organ. He was also active as organist in several local churches. He served in the Army Air Corps of World War II, and was a mason of Lodge 130. He belonged to several zoological societies, and was secretary and trustee of the Maryland Association of Biology Teachers and a past Director of the Historical Society of Harford County. He also served on the Harford County environmental advisory board, the Maryland and Harford County Forest Conservancy Boards, the Deer Creek Watershed Association, the Harford County council's tree and forest preservation committee, and the Harford Glen Foundation.

Dr. Hathaway received an "Outstanding Educator of America Award" from Phi Delta Kappa in 1975, was listed in "Who's Who in the East" and "American Men of Science". His survivors include Patricia, his wife of 46 years, three children and three grandchildren.

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A "Monstrous" *Lucanus elephus* (Coleoptera: Lucanidae) from Maryland

C. L. Staines

"Monstrous" beetles have always been of interest to collectors. Balazuc (1947, 1969) cataloged nearly 700 natural occurrences of beetles having malformed or branched appendages. Most of these beetles are in four families very popular with collectors- Carabidae (including Cicindelinae), Scarabaeidae, Lucanidae, and Cerambycidae (Cooper 1992).

Lucanus elephus Fab. (Coleoptera: Lucanidae) reaches it's northern range limit in Worcester and St. Mary's Counties, Maryland (Staines 1986). A specimen of *L. elephus* collected by R. A. Bean in St. Mary's County, Lexington Park on 04 July 1992 has the left mandible about one-half the length of the right. Male *L. elephus* (Fig. 1A) typically have the mandibles as long as the elytra, the head wider than the pronotum, a distinct crest above the eyes, and the labrum with the apex acute. The female has the mandibles shorter than the head, the head narrower than the pronotum, no crest above the eyes, and the labrum rounded at the apex. Examination of these characters showed that the specimen was not a gynandromorph but a male with anomalous mandibles (Fig. 1B).

Figure 1. A, normal male of *Lucanus elephus* (49 mm). B, anomalous male of *Lucanus elephus* (43 mm).

Balazuc (1947, 1969) reported a gynandromorph *L. cervus* (L.), but no other lucanid abnormalities. This is the first report of an anomalous *L. elephus*.

The specimen is deposited in the author's collection.

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2643 North Charles Street
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The Maryland Naturalist

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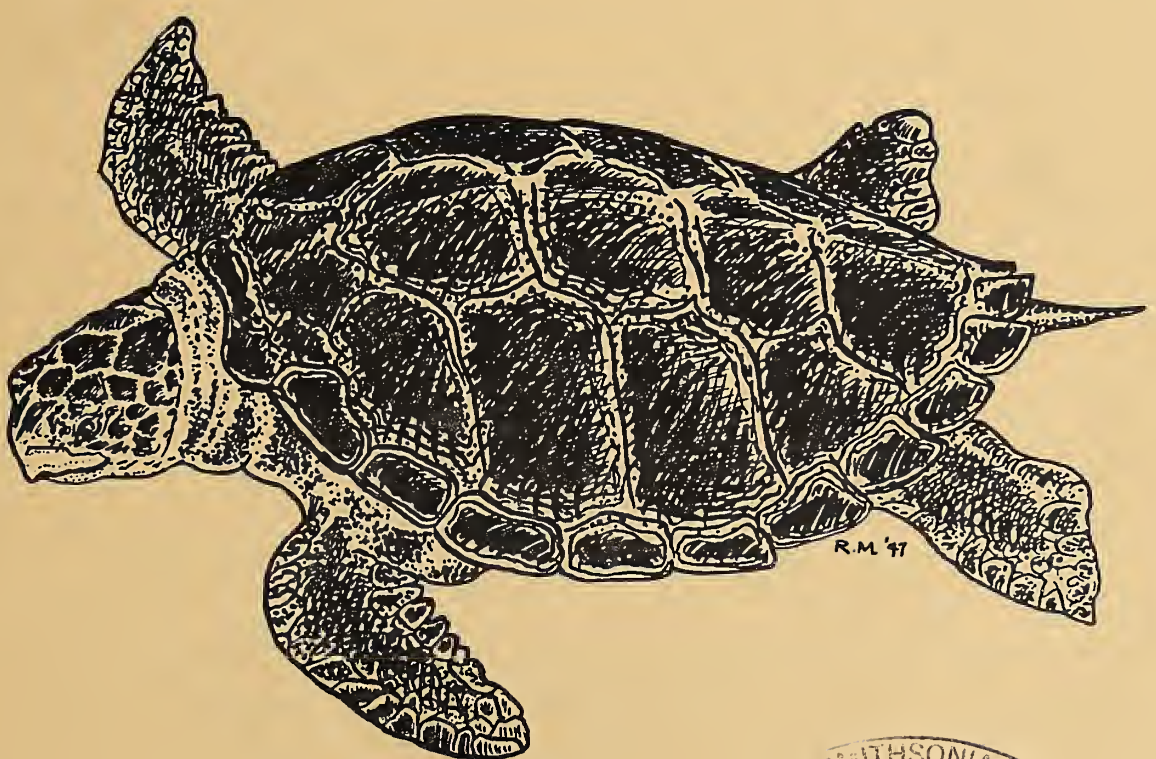

Volume 39, Number 1-2 Jan./June 1995

ISSN 0096-4158

The Maryland Naturalist

Volume 39, Number 1-2 Jan./June 1995

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: January 31, 1996

Cover Illustration: Green Turtle (*Chelonia mydas*). This large species is the least frequently encountered of the four sea turtles that occur in Maryland waters. This pen and ink sketch was done by Romeo Mansueti, and was first published in *Maryland, A Journal of Natural History* (1947, 3[14]:2). Three Green Turtles are known from Maryland, two from the Chesapeake Bay and one from Assateague Island.

The Evolution of 'Eusocial' and the Origin of 'Pollen Bees'

Suzanne W. T. Batra

In this essay, I discuss 'eusocial', an unexpectedly popular but confusingly misused word, and various concepts associated with it. Here I also introduce a needed new term, 'pollen bee', to concisely describe a widespread and growing concept. It should thus become both popular and precisely applied. Both of these terms and ideas are related, because they have been influenced by our interest in, and familiarity with, honey bees. This situation may be due to our innate, primeval taste for honeyed sweetness.

Scientists are often accused of using jargon by a public that does not understand our need to continually create new terms, so that we may accurately and succinctly describe and discuss newly-discovered wonders of nature and new ideas. Sometimes, disagreement among scientists may result in confusion and unnecessary verbiage. A recent example is "HIV, the virus that causes AIDS". How much ink, paper, and attentiveness have been expended on the phrase, "... the virus that causes ..."? Perhaps we should just call it either the AIDS virus, named after the disease symptoms, or HIV, after the physiological mechanism, as we do with other microbes. Fortunately, the words for HIV and AIDS are usually no longer spelled out! When the public media notice a scientific advance, novel, arcane terms may suddenly become widely disseminated. In order to avoid confusion, misuse, and inexact fixation in our vocabulary, we scientists need to carefully explain concepts and terms to the public, especially to media reporters. This is often difficult, because some reporters have little or no scientific background, and they are also often working hastily, under stress, in order to meet deadlines. Unfortunately, some of us do not want to be troubled, or we simply assume that others understand our research. Because we are being paid to enjoy the luxury of collecting, playing with, and generally obsessing about "bugs", we need to explain why we do so. Scientists in general, and entomologists in particular, have an undeserved negative public image, which is exacerbated by the entertainment industry. I never could understand why this situation exists, because our technological society (including the entertainment industry) depends on science.

The evolution of 'eusocial' demonstrates what can happen when a word and its concept are not carefully shepherded into literary society. The idea began germinating in 1960, while I was working on my doctorate. I studied the secretive underground social life of some nondescript, dark little sweat bees (Halictidae), then called *Lasioglossum zephyrum* (Smith). At that time, the societies of such bees were termed 'primitively social.' Honey bees, and stingless honey bees, with their well-defined castes, were 'highly social' bees. The dance language of honey bees was then being popularized, and research on their pheromones was beginning. Honey bees were admired as the most sophisticated of insects, the most highly evolved, just as men (sic!) thought that they were the highest among the animals, even godlike. Nevertheless, some entomologists had started to probe the social lives of bees belonging to other genera. This was not easy, because, at the time, adequate methods for rearing them and observing their behavior had not been developed (except for bumble bees). This contrasts with the centuries during which honeybee keeping was perfected, and the numerous beekeepers and scientists who spent their lifetimes studying honey bees, usually with relatively adequate funding for such research.

I arrived on the bee scene after having studied leafcutting, fungus-growing attine ants. I had been much impressed with these ants' complex behavior, and at first, I was a little dismayed that I was required to study halictine bees rather than ants. Soon, I became fond of these bees, as they ran around, antlike, in the ant-farm-like observation chambers that I had invented for them. I was able to observe all aspects of their surprisingly complicated underground lives, distinguishing among individuals by marking each with different bright dots of enamel. Somehow, it didn't seem right to call them 'primitive'; to me they just seemed different from honey bees, also there was (and is) no evidence that honey bee social structure evolved from these so-called 'primitive' societies- although they may well have. Thus, in 1966, I coined 'eusocial', meaning 'truly social' as a simple, euphonious term to replace 'primitively social'. It was discreetly published in a research report on halictine bees (Batra 1966, p. 375): "Eusocial behavior, in which the nest-founding parent survives to cooperate with a group of her mature daughters, with division of labor. Eusocial behavior as seen in halictines, *Bombus* and *Allodape,* differs markedly from the type of highly complicated social organization seen in the Apini and Meliponini, in which the queen is morphologically and physiologically modified and unable to found a nest unaided by workers (i.e., there is no solitary phase in the life cycle)." Unfortunately, I did not coin a comparable word for honey bee societies at that time, probably because this article concerned only halictine bees. I did believe (and still do) that eusocial bees (and other eusocial insects such as most ants and some social wasps) actually have a superior type of queen. She is, after all, a single working mother (the foundress), who is capable of performing all duties (totipotent), and does so, until her daughters emerge to help her. By contrast, queen honey bees resemble parasites, because they have lost many of their faculties, always being totally dependent on workers (the queen's sisters, half-sisters or daughters). Such is one trend toward the more highly evolved!

Meanwhile, I abandoned sociobiology, for lack of enough time to study it, much less to keep up with rapid progress in the field, and 'eusocial' took on a lively life of its own, creeping into review articles, then into textbooks, where it was used to describe honey bee societies (as 'highly eusocial'), which defeated the purpose of its coinage. Belatedly, in a 1977 review article (Batra 1977, p. 291), I coined 'hypersocial' to describe honey bee societies: "The single nest-founding female eusocial bee at first performs all duties; then when the daughters mature, they remain in their natal nest and serve as workers, and the foundress remains as the egg laying queen. Hypersocial here is coined to refer to the very different social arrangement of honey bees and stingless bees in which the queen is structurally and behaviorally specialized only for egg laying; she cannot begin a new nest without the help of a swarm of workers." But this was too late. 'Eusocial' moved right along, conquering new territory, and being used to describe societies of termites and even naked mole rats, in which the solitary nest-founding female (foundress) is accompanied by a fulsome stud rather than a full spermatheca, and her offspring workers are of both sexes, as are termites. Later, it was applied to a phase in the development of a colony of social animals, which may also go through other phases in their relationships among foundresses (queens) and workers. During recent decades, research in sociobiology has discovered a marvelous diversity and complexity of additional social relationships, which require distinctive naming, in order to avoid confusion. Still, there is something appealing about 'eusocial' that kept expanding its horizons, while reducing its precision. I see it used popularly everywhere as jargon, by now meaning no more than simply 'social'. I couldn't bring 'eusocial' back into the fold, but another opportunity for coinage

has arisen. We're discussing a 'group' of animals that has twice the number of species as the birds, and five times the number as the mammals. What do you colloquially and collectively call bees (Apoidea) that are not honey bees, including stingless honey bees? When I speak or write about pollination for a general audience, it has been necessary to begin with a lengthy explanation, to the effect that, yes indeed, there are bees that are not honey bees, and no, they don't store honey that people can harvest, and furthermore, they do much of our pollination. Some people recognize that bumble bees are indeed bees, and a few know about carpenter bees or sweat bees, but they want to include yellowjackets and other wasps in their world view of 'bees'. This is a real difficulty for many of us who study pollination and bee biology. It came up as a topic for discussion, analysis, and a vote at the well-attended August 1992 International Workshop on non-*Apis* Bees, held at Utah State University. The terms that have been used in the past, and the varied reasons why they are unsatisfactory are listed here.

1. 'Solitary bees' - No good, because many bee species are social.

2. 'Native bees' - No good, because some, notably the alfalfa leafcutter bee, are introduced.

3. 'Non-Apis bees' - No good, because it is defining by a negative, as if most mammals were to be called 'non-apes'. Also, such bees are the norm (over 20,000 bee species), rather than the exception (only 7 species are *Apis*).

4. 'Wild bees' - No good, because honey bees can go 'wild' (feral, or else wildly stinging). Also bee species are increasingly coming under management or being 'tamed'. 'Wild' tends to frighten people, due to the 'killer bee' scare.

After discussing these and other options, the term 'pollen bees' was suggested by J.D. Thomson, of the State University of New York, Stony Brook. This term provides a balanced counterpoint or contrast to the term, 'honey bees' and emphasizes these bees' valued role as pollinators, as well as the fact that they don't yield useful honey. A vote was taken, and the term was adopted, to refer collectively to all bees (Apoidea) except the true honey bees (7 species of *Apis*), and their close relatives, the tropical stingless honey bees (many species of *Melipona* and *Trigona*).

Although some species of pollen bees, such as bumble bees and certain sweat bees are 'eusocial', only the honey bees are 'hypersocial'. The eusocial and other pollen bees were managed originally for pollination services, but the hypersocial bees were first managed (or domesticated) for the sake of their honey and wax yields. Honey bees were not managed for the pollination of crops until the middle of this century, when natural populations of native pollinators were decimated by pesticides and modern agricultural practices.

In order to help everyone remember the difference between honey bees and pollen bees, I have composed the following ditty:

POLLEN BEES

Pollen bees, pollen bees,
People will ask, "What are these?"
We can't take their honey,
We can't use their wax.
All they've got going
     are pollination attacks.
Roll in that pollen, bees.
Shake out that pollen, bees.
Stuff that pollen
     into neat hindleg packs!
In your fuzz, as you buzz.
Dust it all around the world
     from your knees.
Golden grains ....
They won't make us sneeze,
     when they're on pollen bees!

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Occurrence in Southern Maryland of the Carolina Satyr (Satyridae: Satyrinae)

John H. Fales

Introduction

Opler and Krizek (1984) note that the Carolina Satyr, *Hermeuptychia sosybius* (Fabricus), is found in "southern New Jersey and the entire southeastern area south and west to southern Texas and on into most of the tropical and temperate portions of the American tropics." The New Jersey population is disjunct from the rest of the species' range, which runs south and west from southern Maryland.

This species is extremely rare in Maryland (Fales 1974). Clark (1932) reported that, "This common southern species is to be looked for in the vicinity of the District of Columbia." Clark and Clark (1951) noted, "on the Coastal Plain (of Virginia) this species is found everywhere in pine and mixed woods." They mentioned that there are three broods; and it appears shortly after the third week in April. Of interest is the fact that Woodbury (1994) in his Butterflies of the Delmarva does not mention this species.

Harris (1972) stated, "The Carolina Satyr flies close to the ground and may be found in grassy areas and in open woods. It is smaller and darker than our other Wood Satyrs." Opler and Malikul (1992) stated that this small species is unmarked on the upper side but below both wings have series of small yellow-rimmed eye spots. The caterpillar is light green with darker green stripes covered with yellow tubercles. The larvae feed on grasses.

Maryland Records

Robert S. Simmons (Simmons and Andersen 1961) found a colony of the Carolina Satyr on July 28, 1960 two miles south of White Plains in Charles County. This was the first record for this species in Maryland. Then on August 4, 1960 W.A. Andersen found another colony seven miles to the south of the first record.

On August 21, 1960, 25 days after the first record in Charles County, the author and Geoffrey S. Parker found the Carolina Satyr on Mill Bridge Road at Hellen Creek in southern Calvert County. This area was visited numerous times in the years since; and it was found there only once, on July 22, 1982. The next record was in the northeast corner of a wooded area at the intersection of Route 4 and Parran Road in southern Calvert County in the summer of 1976. The exact date and specimen are currently unavailable. During a butterfly survey of Flag Ponds Nature Park, bordering the Chesapeake Bay in Calvert County, Carolina Satyrs were found on September 11, and October 2 and 9, 1990. Then on August 11, 1991 this species was found in a wooded area of the Jefferson-Patterson Park on the east shore of the Patuxent River in southern Calvert County. The last record to date in Calvert County was a worn specimen taken in a wooded area behind the Northern High School at Chaneyville in the northern part of the county on July 24, 1993.

In 1992, the writer and Richard H. Smith, Jr. surveyed the butterflies of the U.S. Naval Surface Warfare Center on the Potomac River at Indian Head in Charles County. That survey was conducted at the request of the Maryland Department of Natural Resources (Maryland Natural Heritage Program). The author found Carolina Satyrs there in fair numbers on June 7 and 18, and on July 28. Richard Smith found one other specimen (worn) on August 29. The June records were the first spring records for this species in Maryland.

The Maryland Natural Heritage Program (1994) lists this species as Rare, and places it on their "Watch List." It is surprising that this species has not been found in St Marys County, the most southern county on the Western Shore of Maryland. Previous mention of this butterfly from St Marys County (Fales 1984) was based on an unsubstantiated record.

All Maryland records that are known to the author are summarized in the following tabulation. I would welcome information on any records not mentioned here.

Location	County	Date	Wing Expanse (mm)	Proboscis Length (mm)	Authority
White Plains	Charles	7/28/60	-	-	Simmons
South of White Plains	Charles	8/4/60	-	-	Andersen
Mill Bridge Road & Hellen Creek	Calvert	8/21/60	34	-	Fales & Parker
Route 4 & Parran Road	Calvert	Summer 76	-	-	Fales
Mill Bridge Road & Hellen Creek	Calvert	7/22/82	-	-	Fales
Flag Ponds	Calvert	9/11/90	-	5	Fales
Flag Ponds	Calvert	10/2,9/90	-	-	Fales
Jefferson-Patterson Park	Calvert	8/11/91	31	-	Fales
Indian Head	Charles	6/7/92	30	-	Fales
Indian Head	Charles	6/18/92	-	-	Fales
Indian Head	Charles	7/28/92	31,32	3,3	Fales
Indian Head	Charles	8/29/92	-	-	Smith
Chaneyville	Calvert	7/24/93	33	-	Fales

The wing expanses of six specimens measured averaged 31.8 mm. Opler and Malikul (1992) reported a wing expanse range of 32-38 mm for this species. The proboscis lengths noted here are interesting. Since Satyridae are not flower feeders, their proboscis lengths in proportion to body lengths are the shortest of all butterflies.

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Notes on Two Rare Maryland Tiger Beetles (Coleoptera: Cicindelidae)

John D. Glaser

A little over a decade ago, I reviewed the tiger beetles (Coleoptera: Cicindelidae) of Maryland for the *Maryland Entomologist*, assembling at that time all that was known about these interesting beetles in our State (Glaser 1984). The review drew upon the larger museum and private collections, the literature, and my own fairly exhaustive collecting efforts for cicindelids. A portion of the paper was speculative about species whose overall range includes Maryland but were not yet recorded from the State, as well as a few with historical but no modern records. The discovery of two such species, one from each category, is the subject of this note.

Cicindela formosa Say is a polytypic species ranging from the Rockies east to the Atlantic coast, excluding the southeastern states. Six subspecies are currently recognized, based mostly on color and extent of pale maculation of the elytra. The base color of the beetles is red or purple in the west and brown to black in the eastern populations, intergrading in the Mississippi drainage. Maculation varies from absent to expanded to nearly all white elytra.

The eastern race, *C. formosa generosa* Dejean (Figure 1A), occurs commonly in southeastern Canada, in the northeast U.S. and in the upper midwest, but fragments into scattered populations through Pennsylvania, Ohio, and the Mississippi drainage. With the exception of a short series of old specimens in the USNM collection bearing the label "Campbell Co., Virginia", perhaps mislabelled, and a recently discovered population along the Ohio River in Mason County, West Virginia (Acciavatti et al. 1992), the species is not known to occur further south, and more to the point, not from Maryland. Thus, it is of considerable interest to be able to report the species from Maryland, and even more remarkable that the site of the colony is the summit of Roundtop Hill in Washington County, at least 100 miles distant from the nearest extant population.

I discovered the colony in mid-June of 1992 in the course of routine geologic mapping. The site is the floor of a small abandoned sandstone quarry on the crest of Roundtop, a rather isolated, steep-sided hill flanking the Potomac River about three miles southwest of the town of Hancock. The quarry floor, consisting of thick, loose sand weathered from the friable sandstone face, is level and opens to the west, creating a small apron of bare sand, totaling barely 300 square feet. At the time of my first visit, tiger beetles were common at the site, consisting mostly of *Cicindela tranquebarica* Herbst, a widely-distributed species which is likely to be encountered in any open area in Maryland in the Spring and Fall months. The *C. formosa* were thinly intermixed in the larger *C. tranquebarica* population, with about half-dozen individuals identified. Two voucher specimens were collected and are retained in the author's collection. I returned to the site in mid-September of 1992, and again in the Fall of 1993 and 1994, finding essentially the same mix of species on each visit. It would appear, then, that a very small, but viable population of *C. formosa* exists at Roundtop.

One can only speculate on how *C. formosa* arrived at this unlikely location. Dispersal of tiger beetles with broad environmental tolerances such as *C. tranquebarica* or *C. punctulata*, especially as larvae, is easily accomplished, and such species are apt to turn up anywhere. But

C. formosa is very demanding in terms of habitat. Deep sand which is loose, dry, and bare or very sparsely vegetated is required for this species. This is a niche which is scarce indeed in the Appalachians, and pretty much limited to just the situation obtained at Roundtop. The closest similar sand habitat lies a few miles across the Potomac in West Virginia, where U.S. Silica operates a complex of sandstone quarries. The property includes abandoned openings similar to that at Roundtop which might host *C. formosa,* but the company is reluctant to allow a search for fear that the discovery of any "rare" biological entity on their property might bring restrictions on their quarrying activities. Whether *C. formosa* exists there or not, the striking fact is that no known colony of the species occurs within 100 miles of Roundtop, nor is there the requisite sand habitat within a fifty mile radius. It is difficult to envision the dispersal route which led this species to the Roundtop site.

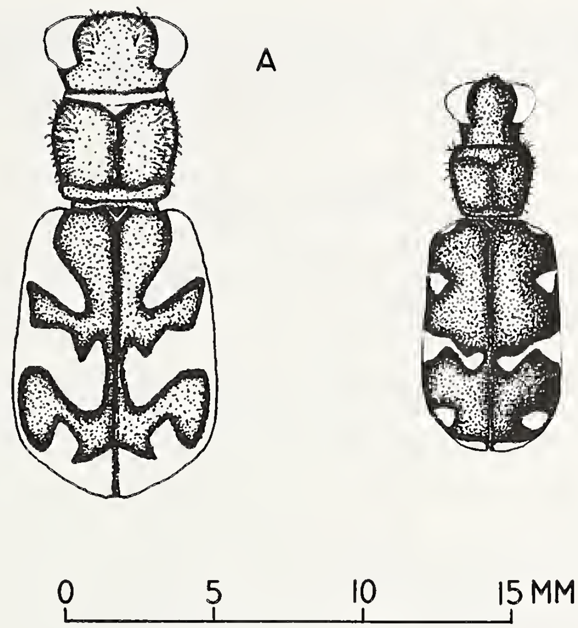

Figure 1. A, *Cicindela formosa generosa* Dej. B, *Cicindela patruela patruela* Dej.

The second species to be considered here is *Cicindela patruela* Dejean (Figure 1B). Although historically known for Maryland, there are to my knowledge no recent records, in fact none within the past fifty years. The handful of existing records are of single specimens collected from the Baltimore-Washington area west to South Mountain.

Cicindela patruela is another species associated with dry sandy habitats which are bare or with sparse, low vegetation. Like *C. formosa,* the adult beetles are active in the Spring and Fall months. Our subspecies is the nominate form, which is typically green or blue-green with

white elytral markings as shown in the accompanying figure. It ranges from the upper midwest across into the northeastern states and down the Appalachian chain to Georgia, in widely-scattered colonies.

A large colony of *C. patruela* inhabits an abandoned sandstone quarry in Preston County, West Virginia, just fifteen miles from the Maryland border, but a thorough investigation of similar quarries in western Maryland proved negative. Success in finding the species came in an unexpected location in serendipitous fashion. Routine geologic fieldwork in the Bear Pond Mountains of western Washington County took me in late August of 1994 to the southern flank of Hearthstone Mountain, where the elusive *C. patruela* was at long last discovered. The colony inhabits a partly overgrown wood road leading north up the mountain slope from AT&T Road. Beetles were observed over a 500 yard reach of the road, or from about 1300 feet to 1600 feet elevation, foraging about on intermittent short stretches of bare sand along the track. The sandy substrate derives from weathering of the sandstone bedrock which forms the south flank of the mountain. The surrounding woodland is unusually open, consisting of widely-scattered trees, mostly oaks, amidst a dense blueberry understory with sporadic grassy patches.

About a dozen individuals were seen on the first visit, with two voucher specimens taken. A return visit in mid-September produced similar results. It would appear that the colony is small, but significant in view of the general scarcity of the species in Maryland.

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Distribution and Habitat Associations of the Eastern Mud Salamander, *Pseudotriton montanus montanus*, on the Delmarva Peninsula

Christopher M. Heckscher

Introduction

The Eastern Mud Salamander (*Pseudotriton montanus montanus*) is found on the Atlantic Coastal Plain from southeastern Louisiana north to southern New Jersey (Conant and Collins 1991, Martof 1975). This species has apparently eluded many experienced herpetologists despite its widespread distribution, and is considered rare or uncommon throughout much of its range. On the Delmarva Peninsula (Figure 1), *P. m. montanus* has been previously reported from only four localities in Delaware (Conant 1945, 1957), and five localities in Maryland (Conant 1945, Harris 1975). There are no records from Accomack or Northampton Counties, Virginia.

Delaware Records

The last published Delaware record of *P. m. montanus* was a specimen found in March of 1956 by Joseph M. Bauman (Conant 1957). Additionally, three general localities were previously reported in Conant's 1945 checklist of amphibians and reptiles from the Delmarva. In 1993 I discovered two individuals from separate sites in Delaware, neither of which represented previously reported localities (R. Conant, pers. comm.). Both sites were lowland palustrine forests on the Coastal Plain of Sussex County. The first individual was found 28 April 1993 near the confluence of Broad Creek and the Nanticoke River, concealed within relatively thick sphagnum moss (>2 inches in depth) in a tidally influenced coniferous (Atlantic White Cedar-Loblolly Pine) palustrine swamp. The salamander, which was captured for examination and released, had features typical of *P. m. montanus*; dark red-brown dorsum with round black spots, brown iris, blunt snout and a pink ventral surface (Conant 1957, Conant and Collins 1991). The second individual was found 5 August 1993 within a palustrine deciduous (Red Maple) swamp in eastern Sussex County. That salamander was found after removing the top 3-4 inches of muck within a seepage area adjacent to a freshwater tributary. It was captured attempting to escape through the mud in which it had been submerged. The specimen was retained for confirmation, photographed, and subsequently released at the collection site several weeks later. A photograph of that specimen (taken by Jim White) has been deposited at the Natural History Society of Maryland. In 1994 an additional observation in Delaware was reported by Frank Hirst (pers. comm.), who had previously found *P. m. montanus* in New Jersey and Maryland. The individual observed by him was also discovered in a seepage area within a deciduous palustrine forested swamp adjacent to a tributary of the Nanticoke River, approximately 3.1 kilometers northwest of the 1993 Sussex County locality.

Maryland Records

Published localities for this species in Maryland counties on the Delmarva Peninsula include two given in Conant's checklist (1945), one from J. A. Fowler in Queen Annes County (Conant 1957), and two additional reports by Harris (1975) in Worcester County. However, the source of the latter two reports and the specific localities are unknown (A. Norden, pers. comm.). In addition, a specimen collected in 1949 from Wicomico County resides at the U.S. National

Museum of Natural History, Smithsonian Institution. Because the locality description for that specimen is extremely general ("17 miles northeast of the Nanticoke River") I was not able to determine with certainty whether or not it was taken from a previously reported Wicomico County location. Additionally, Frank Hirst (pers. comm.) reported two adult *Pseudotriton* observed in Worcester County, one from Nassawango Creek northwest of Snow Hill (1981) and the other from Pikes Creek north of Stockton (1979). At the latter site, Hirst and Arnold Norden (pers. comm.) also observed a clutch of *Pseudotriton* eggs with large, well developed, unpigmented embryos on 7 May 1994. The eggs were beneath a moss covered stick in a cool seepage area. Although the adult *Pseudotriton* observed by Hirst and the eggs found by Hirst and Norden were not confirmed as *P. montanus*, Harris (1975) indicates that only *P. montanus* reaches the lower half of the Delmarva Peninsula.

Discussion

The paucity of Delmarva records from 1956 to 1993 is noteworthy since much herpetological work was undertaken in the region during this period. However, the species' apparent rarity may be primarily due to the secretive nature of *P. m. montanus*, thus attributing the lack of records largely to insufficient inventory methods. Indeed, Conant (1957) speculated that the species was not rare in this region. However, subsequent field surveys (methods described below) during 1993 and 1994 within seemingly suitable habitat did not reveal additional localities in Delaware. This suggests that *P. m. montanus* populations may have suffered from the loss or degradation of wetlands associated with agricultural practices and urbanization. Like many Delmarva species, the mud salamander may face additional threats from further wetland alteration, fragmentation, and subsequent isolation of populations. Therefore, I believe this species deserves conservation attention until its status on the Delmarva is determined.

Twelve of the fourteen reported Delmarva sites occur within a centralized area of the peninsula (Figure 1), and six of those are from the Nanticoke River watershed. It is unclear whether this is primarily a result of: 1) concentrated herpetological surveys in this area; 2) the natural distribution of the species; or 3) the current distribution of the species as a result of widespread habitat degradation throughout surrounding portions of Delmarva. Indeed, riverine palustrine forests remain relatively intact in this area and may sustain an extensive population of *P. m. montanus*. However, detailed life history information on this species is lacking (Bruce 1975), and it is therefore difficult to speculate on dispersal capabilities and, hence, metapopulation interactions. Inventories targeting the mud salamander are needed throughout the Delmarva Peninsula to determine its true distribution in this region.

Examination of known records (both current and historic) indicates that muddy seepage areas within relatively pristine low lying palustrine deciduous and coniferous forested wetlands adjacent to rivers and streams, may be the preferred habitat for this species on the Delmarva Peninsula. This agrees with previous discussions by Bruce (1975), Conant (1957), Fowler (1941), and Martof (1975). Research is clearly needed to determine the environmental parameters which influence habitat selection of this species on the Delmarva.

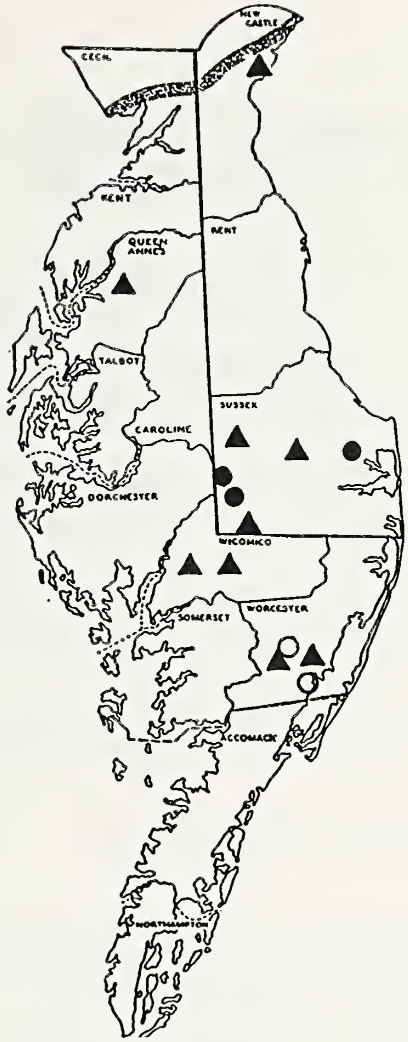

Figure 1. Current and historic locality records of *Pseudotriton montanus montanus* on the Delmarva Peninsula. Triangles indicate historic sites (>15 years old), solid circles indicate recent records, and open circles indicate unconfirmed reports from Frank Hirst. Historic Maryland records are from Harris (1975). Map modified from Tatnall (1946).

Bruce (1975) reported that *P. m. montanus* creates a series of complex subterranean tunnels and chambers in which adults will often lie vertically just below the surface. By quickly raking away the top several inches of mud in potential habitat (which resulted in the August 1993 discovery) one may be able to readily expose tunnels and chambers, allowing for the capture and examination of submerged adults. Herpetologists using this simple method could substantially increase our understanding of the distribution and abundance of this species on the Delmarva and elsewhere. However, due to the paucity of existing records, and the lack of knowledge regarding the species' abundance, I recommend that collected individuals be released once positive identification and photographic documentation has been made.

Acknowledgements

Special thanks to James White (Delaware Nature Society) and Joseph McGlaughlin (Delaware State University) for assistance in confirming the identity of my *P. m. montanus* specimens, to Dr. William Grogan (Salisbury State University) for valuable input and review of this manuscript, and to Frank Hirst and Arnold Norden for relating their observations of these salamanders on the

Delmarva. Dr. Roger Conant provided detailed information on historic records and his assistance is gratefully acknowledged. Also, thanks are due to Arnold W. Norden for assistance in locating other *P. montanus* records.

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Bamboos of Maryland

Donnell E. Redman

When the word bamboo is mentioned, the images which occur to many people include that of the panda feeding on bamboo leaves, of the Bengal tiger stalking through the bamboo grove, or of bamboo-constructed dwellings in exotic places. Actually, bamboos are native to all continents, except Europe. Horticulturists and botanists are well aware that various exotic and one native bamboo species are hardy in various parts of North America, and have been introduced all over the world. While many of the larger species such as timber bamboos (*Dendrocalamus* spp.) require warm climates, others can survive subfreezing temperatures. Exotic bamboos have long fascinated botanists and horticulturists, and interest in studying and growing them is currently undergoing a surge in popularity. There are several nurseries on the west coast that are producing bamboos by cloning, and many garden centers are stocking at least a few bamboos among their ornamental grasses. There is even a bamboo society (American Bamboo Society, 666 Wagnon Road, Sebastopol, California 95472). There are 1000 or so species of bamboo throughout the world (Conover 1994). Approximately half of the known species are native to the new world.

Native Bamboo

Arundinaria gigantea (Walt.) Muhl. (Figure 1) is the only species of bamboo native to North America. Its range includes southern Ohio, Indiana, southern Illinois, Missouri, Oklahoma, Arkansas, Louisiana, Tennessee, Kentucky, Alabama, Georgia, South Carolina, North Carolina, Florida, Texas, Virginia, Mississippi, and Maryland (Hitchcock 1950). Before European colonists arrived in North America, *A. gigantea* grew in vast canebrakes in the lowlands and floodplain forests of the south. Its seed and shelter was of inestimable value to certain wildlife species. Drainage of swamps and destruction of canebrakes probably hastened the extinction of two North American birds, the Carolina Parakeet (*Conuropsis carolinensis*) and the Passenger Pigeon (*Ectpistes migratorius*), and possibly a third, Bachman's Warbler (*Vermivora bachmanii*), which has not been seen since the 1960's (Conover 1994). All of these birds were intimately associated, either for nesting or feeding purposes, with the canebrakes.

This bamboo occurs in loose to dense colonies in damp woods and swamps. In Maryland, this species occurs naturally only on the Coastal Plain (Figure 2). A station just northwest of the Fall-line in the Carney area of Baltimore County is actually a Coastal Plain recess in the Piedmont. It is rare in horticulture on the Piedmont at least as far north as Bluemount in northern Baltimore County.

Arundinaria gigantea is a monopodial type bamboo with a running rhizome as opposed to clumping bamboos (Recht and Wetterwald 1992). Clumping bamboos are not hardy in Maryland and will not be considered here. Unlike most monopodial bamboos, its spreading growth is somewhat limited. However, hard winters may leave the plants leafless and it takes some time for the plants to regrow their leaves. It is not a particularly attractive species for horticulture and due to its protected status, it must be procured from legal nursery sources.

Figure 1. *Arundinaria gigantea* ssp. *tecta*. Flowering and leafy shoot, X0.5; spikelet and floret, X2; summit of culm sheath, outer and inner face, X2. Adapted from Hitchcock (1950).

Arundinaria gigantea is ranked as a globally secure (G5), highly state rare (S1) species with a Threatened and protected state status (Maryland Natural Heritage Program 1994). The rarity of this species is possibly due to predation by insects. As with most bamboos, *A. gigantea* flowers only after a period of years. Observations have shown that the seeds of many colonies are totally destroyed by the larva of insects (Hughes 1951).

At one time, two species of *Arundinaria* were recognized in North America, *A. gigantea* (Walt.) McClure (Gleason and Cronquist 1991) and *Arundinaria tecta* (Walt.) Muhl. (Hitchcock

1950). These bamboos differ in size, *A. gigantea* growing to 7 m and *A. tecta* growing to 2 m in height. A second difference is the presence of leaves on flowering stems of *A. gigantea* and the lack of leaves on flowering stems of *A. tecta*. Finally, the rhizomes of *A. tecta* have peripheral air canals, while the rhizomes of *A. tecta* do not (McClure 1966). However, Hughs (1951) found that many of the clones that he examined in North Carolina had culms of both types, calling into question the separation of these two types. McClure (1973) named three subspecies: *A. gigantea* ssp. *gigantea*, *A. gigantea* ssp. *tecta*, and *A. gigantea* ssp. *macrosperma* (Michx.) McClure, which included the intermediate specimens described by Hughs. Gilley (1943) recognized an "atlantic type" and a "mississippi type" *Arundinaria* without differentiating distinct taxa. McClure (1973) has performed the most extensive studies of these plants and has noted that hybridization may be involved. Turtle (1994) recognized the bamboo native to Maryland as an ecotype. The Maryland Natural Heritage Program (1994) lists the Maryland plants as *A. gigantea*. However, McClure's studies seem definitive and the plants in Maryland will be considered here as *A. gigantea* ssp. *tecta*. McClure's neotype specimen of *A. gigantea* ssp. *tecta* was from Stoney Run in Anne Arundel County, Maryland.

This species has been commonly called Giant Cane, Switch Cane, River Cane, and Canebrake (Turtle 1984). The Maryland Natural Heritage Program (1994) and Brown and Brown (1984) refer to this species as Giant Cane. The name Canebrake usually refers to the plant colony and not to the species. Although this species is capable of reaching 7 m in height and 2.5 cm in diameter in the deep south, in Maryland it does not exceed 2.5 m in height and 0.62 cm in diameter. Considering the size of the local plants, Giant Cane does not seem appropriate, particularly for *A. gigantea* ssp. *tecta*. Switchcane is more appropriate for the subspecies which occurs in Maryland.

Currently, thirteen (13) sites for *A. gigantea* ssp. *tecta* have been documented in Maryland (Figure 2). One colony occurs in Charles County, ten occur in Anne Arundel County, and two occur in Baltimore County. Eight of the ten Anne Arundel County colonies occur within an area of a few miles on the Mountain Road peninsula. One colony, located in Carney in Baltimore County, is the northernmost station in the range of *A. gigantea* ssp. *tecta* (Redman 1995). The remnants of that colony, formerly covering 9.9 hectares, are currently limited to a 20 m x 1 m hedgerow along a rear yard fence in a housing development, and is in competition with Multiflora Rose (*Rosa multiflora* Thunb.) and Japanese Honeysuckle (*Lonicera japonica* Thunb.). If that colony should be destroyed, the colony in Baltimore County's Miami Beach Park will become the northernmost extant station.

I have verified all eleven Maryland sites for this bamboo. The site north of Rt. 50 on the west boundary of Anne Arundel County grows in a straight row in an area which may represent an old logging road on a high wooded hillside above the Patuxent River. This landscape position is atypical for this species and indicates that it may be introduced at that site. There are several specimens in the herbaria of Towson State University (BALT), the University of Maryland (MARY), and the District of Columbia Collection at the Smithsonian Institution (US) which have been misidentified as *A. gigantea* ssp. *tecta*, but actually represent specimens of *Pseudosasa japonica* (Sieb. & Zucc.) Makino or *Sasa palmata* (Bean) Camus. I have placed annotation labels on the herbarium sheets bearing these specimens

Four colonies of *A. gigantea* ssp. *tecta* in Maryland occur on Bibb silt loam, two on Fallsington sandy loam, two on Mixed alluvial, and one colony each on Fallsington loam, Fallsington sandy loam/Woodstown sandy loam, Evestown and Galestown loamy sands, Shrewsberry silt loam, and Collington sandy loam (Kirby and Matthews 1973, Reybold and Matthews 1976, Hall and Matthews 1974). All of these soils are loamy and very acidic.

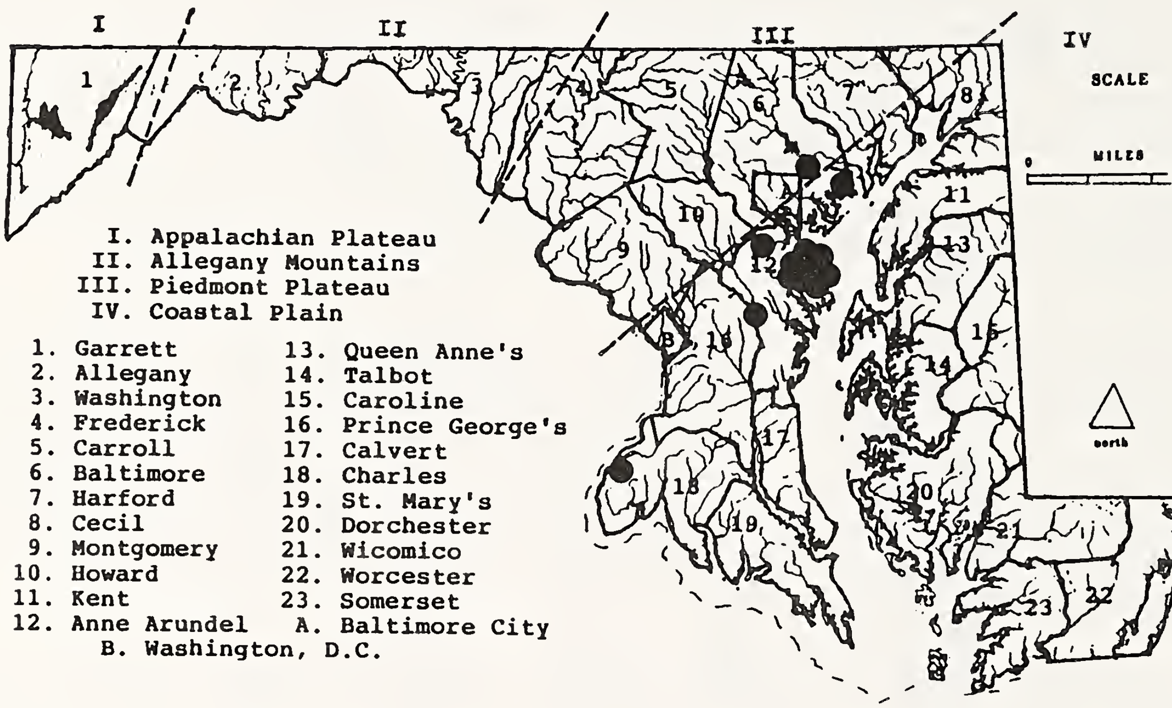

Figure 2. Distribution of natural stands of *Arundinaria gigantea* ssp. *tecta* in Maryland. Known locations indicated by solid circles.

A. gigantea ssp. *tecta* may also occur in Sussex County, Delaware. Around 1976, an agricultural agent sent a specimen to Arthur O. Tucker (pers. comm.) at Delaware State University. The specimen was collected on a farm. Unfortunately, the significance of that specimen was not recognized at the time, and the specimen, the name of the collector and the site of the collection have been lost. No other collections are known for Delaware.

This bamboo species is the host plant to five species of butterflies. These species are the Creole Pearly Eye (*Enodia creola*), Pearly Eye (*Enodia portlandia*), Yehl Skipper (*Poanes yehl*), Lacewing Roadside Skipper (*Amblyscirtes aesculapius*), and Carolina Roadside Skipper (*Amblyscirtes carolina*). It is interesting to note that the Creole Pearly Eye and Lacewing Roadside Skipper have been reported to occur in Delaware (Scott 1986, Opler and Malikul 1992), but have not been reported from Maryland (Fales 1974). However, neither Woodbury (1994) nor the Delaware Natural Heritage Program (1995) have Delaware records, and Richard Smith (pers. comm.), a lepidopterist who has worked with both the Maryland and Delaware

Natural Heritage Programs, knows of no records for either of these butterfly species north of the Dismal Swamp in Virginia.

Those who would like to observe *A. gigantea* ssp. *tecta* in its natural habitat could visit the following sites. However, remember that this plant is protected in Maryland. Permission should be obtained before entering private property:

Anne Arundel County: Poison sumac swamp between Stony Run and the railroad tracks near the BWI Amtrack Station, Harmans (Anne Arundel County and Amtrack properties); forested east branch of Cockey's Creek at Chelsea Beach, Mountain Road peninsula (ownership unknown); forested stream valley bordering west side of Lakeshore Park on west branch of Cockey's Creek, Mountain Road peninsula (private property); Mountain Road peninsula (ownership unknown); South Gray's Bog near the end of North Shore Road, Mountain Road peninsula (Anne Arundel County property); Eagle Hill Bog near Eagle Hill Pond northwest of Eagle Hill Road, Mountain Road peninsula (private property); Blackhole Creek north of Glenn Crest Terrace, Mountain Road peninsula (ownership unknown); thickets on south side of Mountain Road (Rt. 177) east of Maryland Avenue opposite Fresh Pond, Mountain Road peninsula (State property); wooded seep ravine at south end of 200 block New York Avenue in Linwood Village, Mountain Road peninsula (Anne Arundel County and private property); low wooded roadbank ditches bordering Hog Neck Road just south of Mountain Road, Mountain Road peninsula (State property); wooded hillside several hundred feet north of Rt. 50 and 100 yards east of the Patuxent River, Rt. 50 fencing, and adjacent federal property (State property).

Baltimore County: Rear yard fencerow on west side of Harford Road between Andrea Avenue and Joni Court, Carney (private property); low Sweetgum-oak woods toward rear of Miami Beach Park, Essex (Baltimore County property).

Charles County: Three colonies in Green Ash/Red Maple swamp at the mouth of Reeder Creek at its intersection with Chicamuxen Creek tidal marsh (ownership unknown).

The significance of the majority of known sites occurring on the Mountain Road peninsula is unknown. However, the possibility that all of these colonies were once connected is intriguing. It is possible that additional colonies will be located in the future which could change our concept of the distribution of *A. gigantea* ssp. *tecta* in Maryland.

Exotic Bamboos

Many different species of exotic bamboo have been introduced into the United States, including Maryland, within the last 50 years (McClure 1948). Introductions of many species occurred as a result of American incursions into far east countries during and after World War II. The Department of Agriculture introduced *Phyllostachys aureosulcata* McClure (Yellow-Groove Bamboo) as a plant stake and cattle forage (McClure 1948). However, agricultural commercialization of *P. aureosulcata* was never successful and there are many abandoned groves of this species growing along roadsides and in open forests in the United States. Field surveys in Maryland have located colonies in most counties of the Coastal Plain and Piedmont, at least as far west as Frederick County. It is particularly common in Baltimore County. During the severe winter of 1993-1994, many groves were severely damaged, and some were

killed outright. Other exotic bamboo species planted in Maryland include *Phyllostachys aurea* Carriere ex A. et C. Riv. (Golden Bamboo), *P. bambusoides* Sieb. & Zucc. (Fishing Pole Bamboo), *P. flexuosa* A. et C. Riv. (Zigzag Bamboo), *P. nigra* (Loddiges ex Lindley) Munro (Black Bamboo), *P. nuda* A. et C. Riv. (Naked Bristle Bamboo), *P. viridiglaucescens* (Carriere) A. et C. Riv. (Glaucous Green Bamboo), *P. viridis* (R.A. Young) McClure (Green Bamboo), *P. pygmaeus* (Miquel) Nakai (Dwarf Bamboo), *Pleioblastus variegata* (Mak.) Sieb. (White Stripe Bamboo), *Pseudosasa japonica* (Sieb. & Zucc.) Makino (Arrow Bamboo), *Sasa palmata* (Bean) Camus (Palm Bamboo), *Sasa veitchii* (Carriere) Rehder (Kuma Bamboo), *Semiarundinaria fastuosa* (Mitford) Makino ex Nakai (Narihira Bamboo), *Shibataea kumasasa* (Zollinger ex Steud.) Mak. ex Nakai (Kumasasa Bamboo), and probably others. The three most common exotic bamboos in Maryland, in order of their abundance, are *P. aureosulcata, P. bambusoides*, and *S. palmata*.

Those who would like to observe exotic bamboos may visit the following sites. Only a few representative sites which are public or may be observed from public property are listed, and some exotic species are not included:

Anne Arundel County: Roadbank of Commerce Road just north of Bestgate Road, Annapolis (*P. aureosulcata*/ownership unknown); roadbank Northbound Rt. 3 just south of Quarterfield Road *P. aureosulcata*/State property; west bound road bank of Rt. 50 approximately 1/2 mi east of the Patuxent River (State property); swamp stream bordering Obrecht Road west of Jumpers Hole Road (*S. palmata*/private property)

Baltimore City: East side of Linkwood Lane just south of Coldspring Lane, Stony Run Park (*P. pygmaeus*/private property); north side of Northern Parkway several hundred feet east of Falls Road in Mt. Washington (*P. aureosulcata*/private property); hedge in front of 501 Orkney Road, Pen Lucy (*Sasa palmata*/private property); northwest Corner of Pimlico Road and Cross Country Boulevard (*P. japonica*/Baltimore City property).

Baltimore County: Northeast corner of Charles Street and Towsontown Blvd (*P. aureosulcata*/private property); east side of Walthamwoods Road just north of Ebony Road (*P. aureosulcata*/Baltimore County property); North Central Trail just north of Papermill Road (*P. aureosulcata*/ State property), end of Hollow Road at Warren bordering Loch Raven Watershed (*P. aureosulcata*/private property); bank of firetrail 0.5 mi northwest of Seminary Avenue x Dulaney Valley Road, Loch Raven Watershed (*P. nuda*/Baltimore City property); northwest side of Dulaney Valley Road at Old Bosley Road, Loch Raven Watershed (*P. aureosulcata*/ Baltimore City Property; west bank of North Central Trail and bluff above 0.5 mile north of Paper Mill Road, Loch Raven Watershed (*Sasa veitcheii*/State, Baltimore City, and private properties).

District of Columbia: National Zoological Park (many species/Federal property), National Arboretum off New York Avenue (many species/Federal property), center of campus of Catholic University (*Sasa palmata*/university property); Kenilworth Aquatic Gardens (a few species including *P. aureosulcata* and *Sasa palmata*/Federal property); Capitol Building (large groves of *P. aureosulcata* on both sides of entrance/Federal property).

Frederick County: East bank of Catoctin Creek at Rt 180 west of Frederick (*P. aureosulcata*/ county property).

Harford County: Swamp on the northbound side of Rt. 40 just north of Rt. 24 (*P. aureosulcata*/ownership unknown; woods along northeast side of Atkisson Road opposite Lake Vista Drive, Harford Glen (*P. bambusoides*/Harford County property).

Howard County: Bonnie Branch Road 1.3 mi north of Rt. 103, Ilchester (*P. aureosulcata*/ property ownership unknown).

Montgomery County: Beach Drive near the intersection of Rt. 495 and Rt. 185 in Rock Creek Park, just north of D.C. line (*P. viridiglaucescens*/county property).

Prince Georges County: West bank of Patuxent River 30 m. south of Governor's Bridge Road (*P. bambusoides*/State property).

Worcester County: West side of Rt, 611 near Rt. 376, Lewis Corner (*P. aureosulcata*/private property).

Acknowledgements

I wish to thank Judy Cole of the Maryland Department of the Environment, and Richard Smith, independent lepidopterist, for sharing their knowledge of *Arundinaria gigantea* localities with me. Arnold Norden of the Maryland Department of Natural Resources, and Arthur Tucker of the University of Delaware made many helpful suggestions.

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Another Atlantic Leatherback Turtle Observed in the Upper Chesapeake Bay

John Page Williams

Although the Atlantic Leatherback Turtle *(Dermochelys coriacea coriacea)* has been known from the Chesapeake Bay since the early part of the last century (Holbrook 1824, Carr 1952), few records have actually been documented. Hardy (1969) reviewed the Chesapeake Bay records, citing six observations, four of which were from the Maryland portion of the bay. The most recent of those records was a large individual, estimated to weight 600 to 650 pounds, that was caught near Hooper Island in Dorchester County in 1967. Considering the scarcity of records for this large, pelagic species in the middle and upper part of the Chesapeake Bay, the following observations seem worth recording.

On Friday, June 9, 1995, I went fishing with Eugene Murray and George Maurer for several hours early in the morning. We launched my skiff at Sandy Point State Park and headed across the Bay to the "Sewer Pipe", the outfall from the Kent Island Wastewater Treatment Plant that extends from shore out nearly half a mile to a steep dropoff into the old Susquehanna River channel. The Sewer Pipe is a well-known summer and early fall fishing spot.

We had caught and released three rockfish around 16 inches in length when Murray had an exceptionally heavy strike. Whatever it was, it began taking line very fast from his light spinning rig. We followed it south to the Bay Bridge, hoping to get a look at it. I knew that whatever it was, it was too big for Murray to bring to the boat with such light tackle without exhausting it, so my intent was to try to get a look at it then break off the line as close to the hook as possible.

As we neared the bridge, we were stunned to see what appeared to be a 4 foot-long leatherback sea turtle broach in front of us. At first we did not realize that the turtle was what Murray had hooked, but it turned and headed north again. We followed and it broached a second time. This time we got a good look at it, seeing clearly the lengthwise ridges on its shell, and noting its size. By that time it had been on the line for about two minutes. It broached once more and Murray cupped his hand over the reel and pointed his rod tip at the turtle, breaking the line. We could only hope that the sea turtle was subsequently able to rid itself of the nearly barbless jig. Fighting it to the boat to remove the jig would have required a much longer struggle that would have placed tremendous stress on the animal.

At the time this turtle was hooked, the Bay was calm and the water temperature was in the low 70s. The location of this sighting was above Annapolis, approximately 28 miles farther up the bay than the northernmost previous Chesapeake Bay record of a dead leatherback that washed up at Dares Beach in Calvert County. I reported our observation to the Virginia Institute of Marine Science at Gloucester Point on Monday, June 12th. They informed me that there had already been two other sightings of leatherbacks in the Virginia portion of the Bay. Both of those represented large adults, one from Mathews County just north of Mobjack Bay, and the second from around Smith Point. Murray, Maurer, and I felt privileged to have seen this uncommon sea turtle. We wish it a long and healthy life.

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When possible, manuscripts should be submitted on IBM compatible 5¼ inch high density floppy discs formatted for Word Perfect 5.0, 5.1 or other compatible software (this is particularly important with longer manuscripts). If word processing capability is not available, submit manuscripts typed, double spaced, on good quality bond paper with adequate margins. Authors should adhere generally to the *Council of Biology Editors Style Manual.* However, individuality and readability of writing style are encouraged.

Contributions other than short notes may include a brief informative abstract. Payment of page charges is not required for publication in *The Maryland Naturalist.* However, if funds are available, assistance to offset publication costs would be welcome.

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NATURAL HISTORY SOCIETY OF MARYLAND, INC.
2643 North Charles Street
Baltimore, Maryland 21218

The Maryland Naturalist

THE NATURAL HISTORY SOCIETY OF MARYLAND

Volume 39, Number 3-4 July/December, 1995

ISSN 0096-4158

The Maryland Naturalist

Volume 39, Number 3-4 July/December, 1995

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: October 25, 1996

Cover Illustration: Three species of *Notropis* found at Fort Belvoir, Virginia. Top, Brindle shiner (*Notropis bifrenatus*); center, Spottail shiner (*Notropis hudsonius*); bottom, Swallowtail shiner (*Notropis procne*). These drawings, published in the Atlas of North American Freshwater Fishes (North Carolina State Museum of Natural Sciences, 1980), were made by staff artist Renaldo Kuhler. Reproduced here with permissionm from the North Carolina State Museum of Natural Sciences, Raleigh, North Carolina.

Fishes of Fort Belvoir, Virginia

Carl H. Ernst, James C. Wilgenbusch,
Donald R. Morgan, Timothy P. Boucher, and Mark Sommerfield

Introduction

This report summarizes 1993/1994 field collections and observations on the life histories of the fish occurring in the waterways of Fort Belvoir Military Installation, Fairfax County, Virginia, and incidental observations by the senior author since 1972. The purposes of the report are to provide a current species list, and to compile within one paper available life history data for each fish species. We hope that this information will serve as a reference for naturalists, scientists, planners and concerned citizens who wish to study and conserve the aquatic fauna of Fort Belvoir and northern Virginia.

Fort Belvoir is located on the west bank of the Potomac River in Fairfax County, Virginia about 18 km southwest of Washington, D.C. It is crossed by U. S. Route 1 running east to west and Backlick Road running north to south. The installation contains 3,503 ha of land, of which only about one third had been developed prior to 1993. This is one of the largest remaining natural landscapes in the Washington D. C. area. The undeveloped areas contain a variety of landforms and habitats typical of the coastal plain of the mid-Atlantic region. Fort Belvoir is situated entirely on the Atlantic Coastal Plain and elevation ranges from 10 m along the Potomac River shoreline to 50 m in the northeastern portion of the installation. The terrain consists of gently sloping (5% or less) wooded plateaus and flatlands which are dissected by creeks and brooks and their associated floodplains and wetlands. Some of the banks of the ravines formed by the tributaries of the major creeks are steeply sloped to 50% and are surrounded by mature forests.

The open water habitats consist of a drainage system of creeks and small tributaries which flow into shallow semitidal bays and marshes that empty into the Potomac River. From west to east, the three major creeks which cross Fort Belvoir are Pohick, Accotink, and Dogue (Figure 1). Each has formed a semitidal bay at it's mouth. Gunston Cove, formed by the merging of Pohick and Accotink bays, separates the installation from Pohick Bay Regional Park on the Mason Neck Peninsula. Dogue Creek forms another large bay along the southeastern boundary of the Belvoir Peninsula. Each of these bays has low salinity and extensive wetlands with emergent vegetation which provide excellent cover and food for fish. Several other small brooks empty directly into the Potomac River or Accotink or Pohick bays. All of these waterways provide migration corridors for fish entering from the Potomac River.

Accotink, Dogue, and Pohick Creeks drain large watersheds in Fairfax County and hence have extensive floodplains and wetlands adjacent to them. Many have been augmented by beaver activity in recent years (particularly Dogue Creek at the Jackson Miles Abbott Wetland Refuge). There are numerous small tributaries to the creeks, which are typically are ephemeral or intermittent and meandering with undercut banks, and traverse densely forested areas. These conditions are unfavorable for predatory fish and therefore are excellent for many other species, especially cyprinids. Each brook and stream contains alternating pools, where the water slowly flows, and shallow riffles, where the flow is more rapid and the water more oxygenated. The pools are used for breeding sites, while many species of fish forage in the riffles. Water depth is generally shallow, with only a few pools in the main streams as deep as two meters. The bottom substrate varies from mud or sand to gravel or rock, and serves as an important microhabitat for bottom feeders, such as carp, suckers and catfish which prefer a soft bottom, or darters which are usually found in gravel beds or rocky areas. The bottom substrate also plays an important role during spawning, particularly for fish species that construct and defend nest

depressions (sunfish, black basses, some cyprinids). Much drainage on the installation flows under forest canopy and is relatively cool, but some waterways pass through open areas where they are warmed by direct sun.

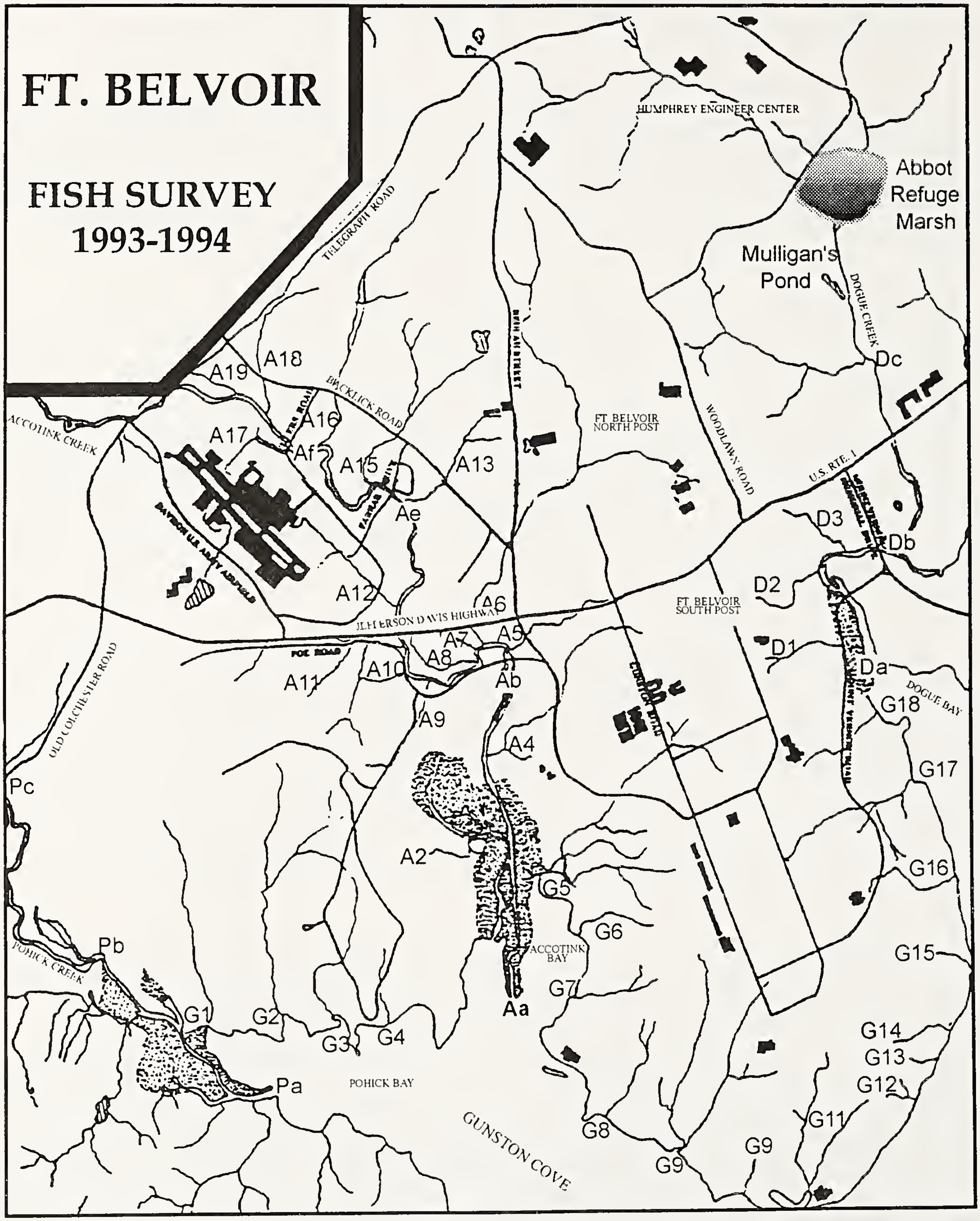

Figure 1. Map of Fort Belvoir, Fairfax County, Virginia, showing primary waterbodies and location of all collection stations surveyed during this study.

Within the aquatic system described above are several habitat features or microhabitats that are important to fish. In the forested wetlands and floodplains along the creeks, debris piles have formed during flood events, creating particularly good sites for black basses, sunfish, and perch. The beaver created ponds are characterized by scattered downed trees and stumps which provide ideal cover for many species of fish amidst a highly eutrophic foraging area. As a result these ponds are inordinately productive for both small cyprinids and catfish, and predatory centrarchid species.

Three manmade impoundments exist at Fort Belvoir which contain fish (Morton et al. 1991): the Golf Course, INSCOM (U. S. Army Intelligence & Security Command), and Mulligans Pond. All three ponds have apparently been stocked with sunfish, perch, or black basses in the past (Steven W. Sekscienski pers. comm.). The first two are not connected to any waterway flowing through the installation, but the latter is connected to Dogue Creek and may have received some of its fish fauna naturally through migration from that stream. Permission was granted to only sample Mulligans Pond.

The undeveloped uplands of Fort Belvoir are covered with various seral stages of hardwood forests (oak, *Quercus*; beech, *Fagus*; tulip tree, *Liriodendron*; etc.), mixed pine (mostly Virginia pine, *Pinus virginiana*) and hardwood forests, and pine plantations (loblolly pine, *Pinus taeda*). A variety of management activities including forest cutting (both clear and selective) resulting in open plots and reforestation, have created a complex of habitats which has had a major influence on stream populations of fish by providing various prey items, affecting productivity and water temperature through the amount of canopy cover, and siltation through erosion.

Methods

Locations and habitat parameters for the 1993/1994 fish collection sites are presented in Appendix 1 and plotted on Figure 1. Fish were collected primarily with a Smith-Root Inc., Model 15A gasoline-powered electrofisher, but some were collected by seining shallow and weedy areas, particularly at Mulligans Pond and the Jackson Miles Abbott Wetland Refuge. Whenever possible, fish were identified in the field to species, sexed, and measured (total body length, TBL), and their numbers recorded prior to release at the collection site. Specimens difficult to identify (especially cyprinids) were brought to the laboratory at George Mason University for further examination. Notes were made of breeding color or sexually dimorphic characters, and of any reproductive or other behaviors observed.

Results

Sampling and observations during 1993/1994 indicate that the fish fauna of Fort Belvoir is diverse and rich in species and numbers. Fourteen of the 19 families (73.7%) and 47 of the 78 species (60.2%) of fish previously reported from northern Virginia waters by Jenkins and Burkhead (1994) have been found on the installation (including *Petromyzon marinus* and *Cyprinella analostana* represented by specimens in the fish collection of the United States National Museum of Natural History, Smithsonian Institution, Washington, D. C. [USNM], and *Ictalurus punctatus* found during a survey of the artificial ponds on Fort Belvoir by Morton et al. 1991). However, the list generated from Jenkins and Burkhead (1994) includes several introduced, extirpated, or anadromous species which have little chance of being found at Fort Belvoir (see below). Families present and the total number of species in each are Petromyzontidae (Lampreys), 2; Lepisosteidae (Gars), 1; Clupeidae (Herrings and Shad), 1; Anguillidae (Freshwater Eels), 1; Umbridae (Mudminnows), 1; Ictaluridae (Bullhead Catfish), 3; Cyprinidae (Minnows, Dace, Shiners), 18; Catostomidae (Suckers), 3; Poecilidae (Livebearers), 1; Antherinidae (Silversides), 1; Fundulidae (Killifish), 2; Centrarchidae (Sunfish and Black Basses), 10; Moronidae (Temperate Basses), 1; and Percidae (Darters and Perch), 2 (Appendix 2).

Cyprinids (18) comprised 38.3% of the recorded species, while centrarchids (10) made up an additional 21.3%. These two groups usually dominate species composition of waterways in eastern North America. Cyprinids were the most abundant of the 43 species collected or observed; 6,675 of 8,909 total fish captures (74.9%). Seven of the ten most abundant species were cyprinids (Table 1). The next most abundant groups were the centrarchids (653 captures, 7.3%), killifish (515, 5.8%), and suckers (355, 4.0%). The most abundant species was *Rhinichthys atratulus* with 2,869 captures (32.2% of total captures), which completely dominated the shallow headwater portions of the Accotink Creek watershed. If combined with the 88 *R. cataractae* collected, the genus *Rhinichthys* accounted to 33.2% of all fish recorded in 1993/1994. *Notropis hudsonius* (972, 10.5%), *Semotilus atromaculatus* (653, 7.7%), *Lepomis machrochirus* (523, 5.9%), *Cyprinella spiloptera* (511, 5.7%), and *Fundulus diaphanus* (508, 5.7%) followed in abundance.

The most uncommon species recorded in the two years were *Nocomis micropogon* (collected once at site Af), *Lepisosteus osseus* (observed once in Accotink Creek), *Perca flavescens* (two specimens from site Aa), *Enneacanthus gloriosus* (two captured at site Db), *Cyprinus carpio* (two specimens at site Ae), and *Lepomis gulosus* (single specimens collected at site Dc and Mulligans Pond).

The species collected in each waterway and at each site, and their relative numbers and sizes (total body length, TBL) are presented in Appendixes 2 and 3. A comparison of the relative fish species richness, diversity and evenness of the waterways sampled is presented Figures 2 through 4. Sites Af and Ab had the greatest species diversity, but diversity was also high at sites A13 and Db. Species richness was lowest at sites A16 and Pb, and species diversity was lowest at Pb. In general, as the headwaters of a tributary brook were approached both species richness and diversity dropped rapidly. This is particularly evident in waterways Ab and G2. However, species richness stayed relatively high in waterway A15 until the headwaters collection site A15g, and species richness increased from the mouth to the headwaters in waterway A19. Usually, the only fish collected in the most shallow headwaters were daces (*Rhinichthys*). Collection site G2c showed the greatest species diversity, while G5, the only seriously polluted waterway sampled (remnants of an oil spill), showed low species richness and diversity except near its mouth and no fish at all at its most polluted site, G5f. Species evenness was rather uniform between waterways when all collection sites within the waterways were combined for comparison.

The high species richness, great species and family diversities, and large numbers of individuals at many sites supports the conclusion that the waterways on Fort Belvoir are at present relatively healthy and little impacted, particularly Accotink Creek which is almost pristine in some stretches. It is hoped that these waterways can be maintained in this condition for the foreseeable future. Information on the fish fauna gathered during this study should serve as baseline data for comparison with any future fish surveys on the installation, and should be consulted when environmental impact statements are required for future development.

The fish living in Fort Belvoir's streams reproduce predominately in the spring or early summer, usually from April into June (Carlander 1969, 1977; Jenkins and Burkhead 1994). Spawning activity seems triggered by water temperatures rising above 16° C. Although no fish were dissected, secondary sexual characters (such as the onset of breeding color, attainment of nuptial tubercles in males, or the extended abdomen of gravid females) or reproductive behavior (courtship, spawning, nest construction or nest defense) were noted to possibly define the breeding season of individual fish species. Reproductive data were recorded for 18 species and are presented in Table 2. These seem to indicate more extensive fall and winter activity in some cyprinids in northern Virginia then has previously been recognized. However, fall males reported as reproductive may have retained characters from the previous season or were just attaining reproductive readiness in preparation for the next spring spawning period. Such males were noted in *Cyprinella spiloptera* and, particularly, *Rhinichthys atratulus*. Gravid fall or winter females were noted in *Luxilus cornutus, Rhinichthys atratulus*, and *Semotilus*

atromaculatus. Again, these females may have been merely yolking eggs for the spring spawning season. Dissections of these cyprinid species in the fall and winter would help determine their breeding cycles at Fort Belvoir.

Table 1: Relative abundance and sizes of fish, 1993-1994.

SPECIES	Frequency of Species	Number of Observations	Maximum Size	Mean Size	Minimum Size
Total Individuals	**8909**				
Rhinichthys atratulus	0.24359	2869	7.5	4.3893	1.0
Notropis hudsonius	0.05483	972	8.6	4.4158	2.0
Semotilus atromaculatus	0.04972	683	19.0	6.8208	1.2
Lepomis macrochirus	0.04252	523	15.6	5.3841	2.5
Cyprinella spiloptera	0.03922	511	7.3	5.5356	2.5
Fundulus diaphanus	0.03566	508	9.0	5.9024	3.4
Clinostomus funduloides	0.02495	381	17.0	5.2638	2.8
Notropis bifrenatus	0.02180	363	7.6	5.1771	1.5
Pimephales notatus	0.01629	241	7.2	4.6490	2.5
Anguilla rostrata	0.01726	216	60.0	22.5074	7.0
Luxilus cornutus	0.01293	202	14.5	8.2005	5.5
Umbra pygmaea	0.01158	186	10.1	5.1887	2.4
Catostomus commersoni	0.00986	152	38.0	7.1921	2.0
Hypentelium nigricans	0.00872	138	15.5	6.1529	3.0
Hybognathus regius	0.00907	131	9.0	4.7840	2.5
Notropis procne	0.00729	118	11.5	8.3034	4.5
Etheostoma olmstedi	0.00598	89	8.0	4.9045	2.0
Rhinichthys cataractae	0.00525	88	8.2	5.8170	3.2
Erimyzon oblongus	0.00454	65	18.5	10.0615	3.5
Lampetra aepyptra	0.00426	62	14.2	9.3355	1.5
Lepomis gibbosus	0.00357	56	16.0	10.5768	5.2
Semotilus corporalis	0.00325	53	16.0	8.6679	4.0
Notemigonus crysoleucas	0.00320	52	10.0	6.2212	3.9
Ameiurus nebulosus	0.00321	51	19.5	8.1216	3.5
Etheostoma olmstedi	0.00304	44	7.0	4.5636	2.0
Micropterus salmoides	0.00208	37	0.0	0.0000	0.0
Gambusia holbrooki	0.00192	25	5.0	2.6640	1.0
Morone americana	0.00101	18	8.3	1.3833	0.0
Lepomis cyanellus	0.00077	11	12.5	8.7636	3.5
Dorosoma cepedianum	0.00062	11	0.0	0.0000	0.0
Lepomis auritus	0.00048	8	14.5	13.9000	13.3
Fundulus heteroclitus	0.00043	7	6.7	5.5000	4.8
Lepomis megalotis	0.00034	6	0.0	0.0000	0.0
Micropterus dolomieu	0.00032	5	8.5	6.9200	6.0
Carassius auratus	0.00025	4	10.2	10.2000	10.2
Exoglossum maxillingua	0.00024	4	7.0	7.0000	7.0
Ameiurus natalis	0.00022	4	0.0	0.0000	0.0
Menidia beryllina	0.00017	3	0.0	0.0000	0.0
Pomoxis nigromaculatus	0.00017	3	0.0	0.0000	0.0
Perca flavescens	0.00011	2	0.0	0.0000	0.0
Lepomis gulosus	0.00011	2	0.0	0.0000	0.0
Enneacanthus gloriosus	0.00011	2	0.0	0.0000	0.0
Cyprinus carpio	0.00011	2	0.0	0.0000	0.0
Nocomis micropogon	0.00006	1	0.0	0.0000	0.0

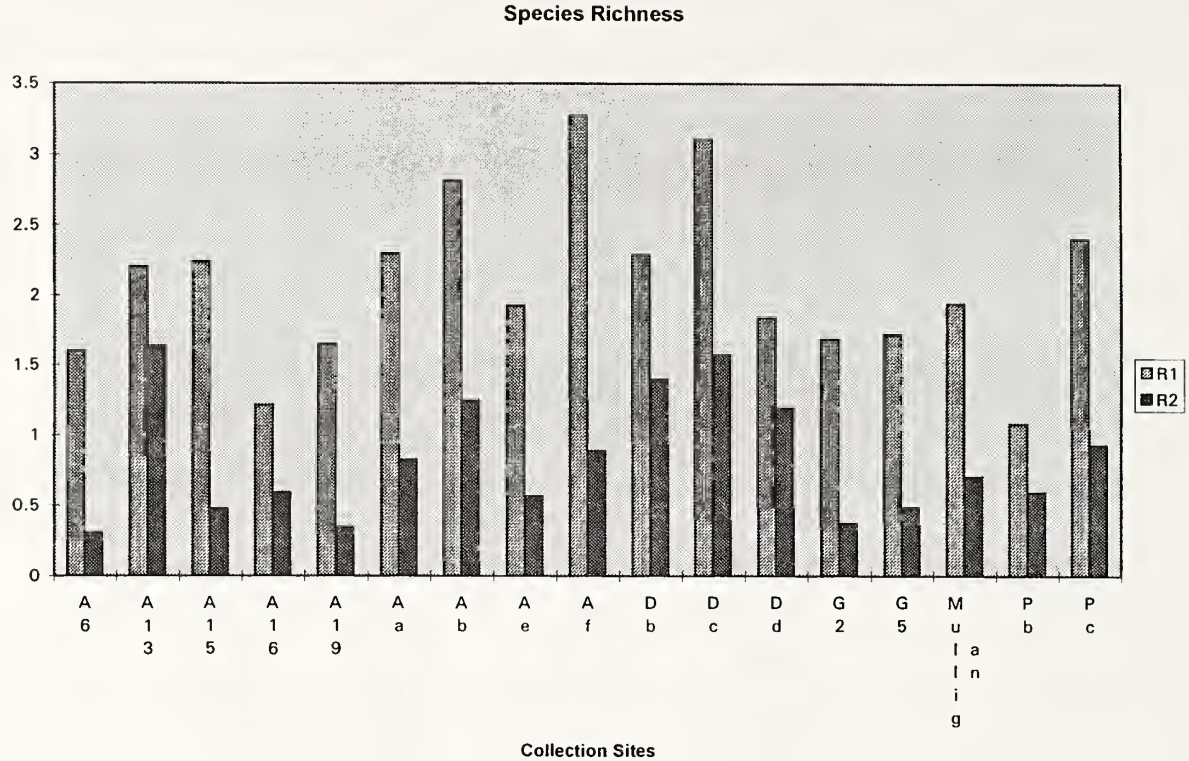

Figure 2. Relative species richness by waterway, 1993-1994

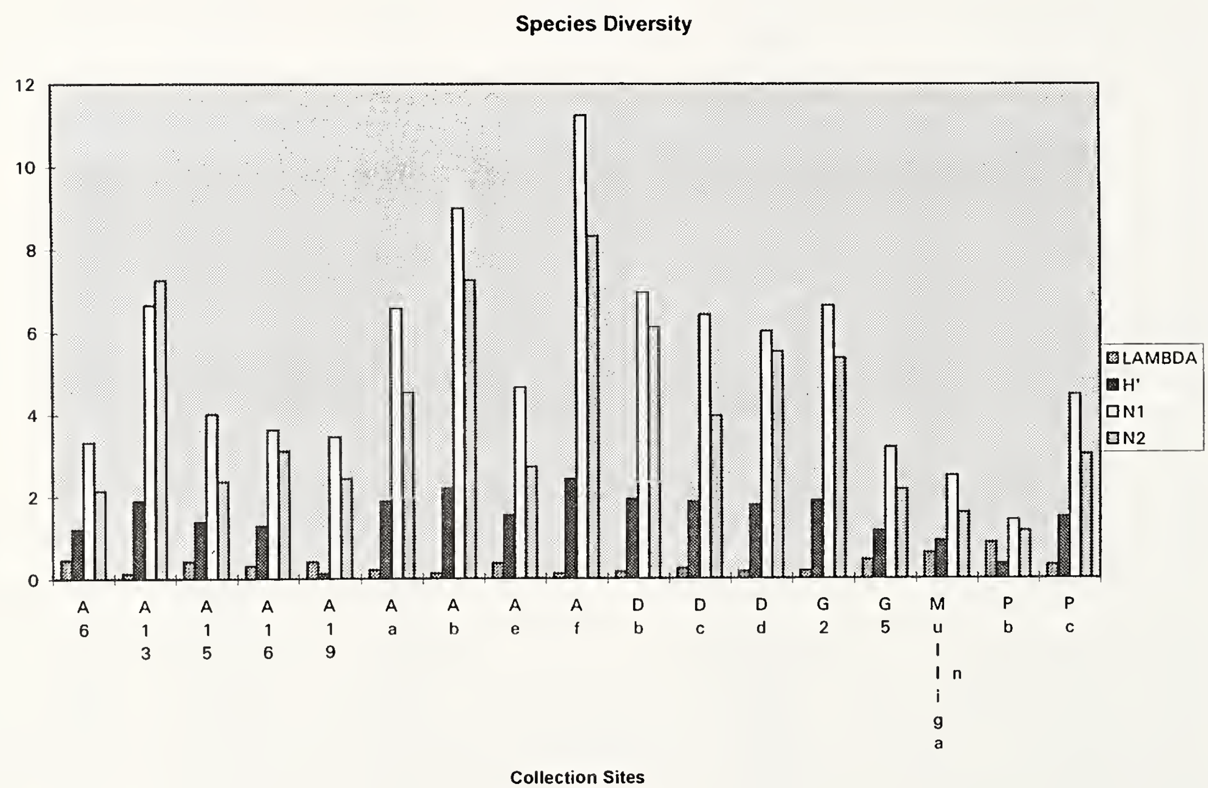

Figure 3. Relative species diversity by waterway, 1993-1994.

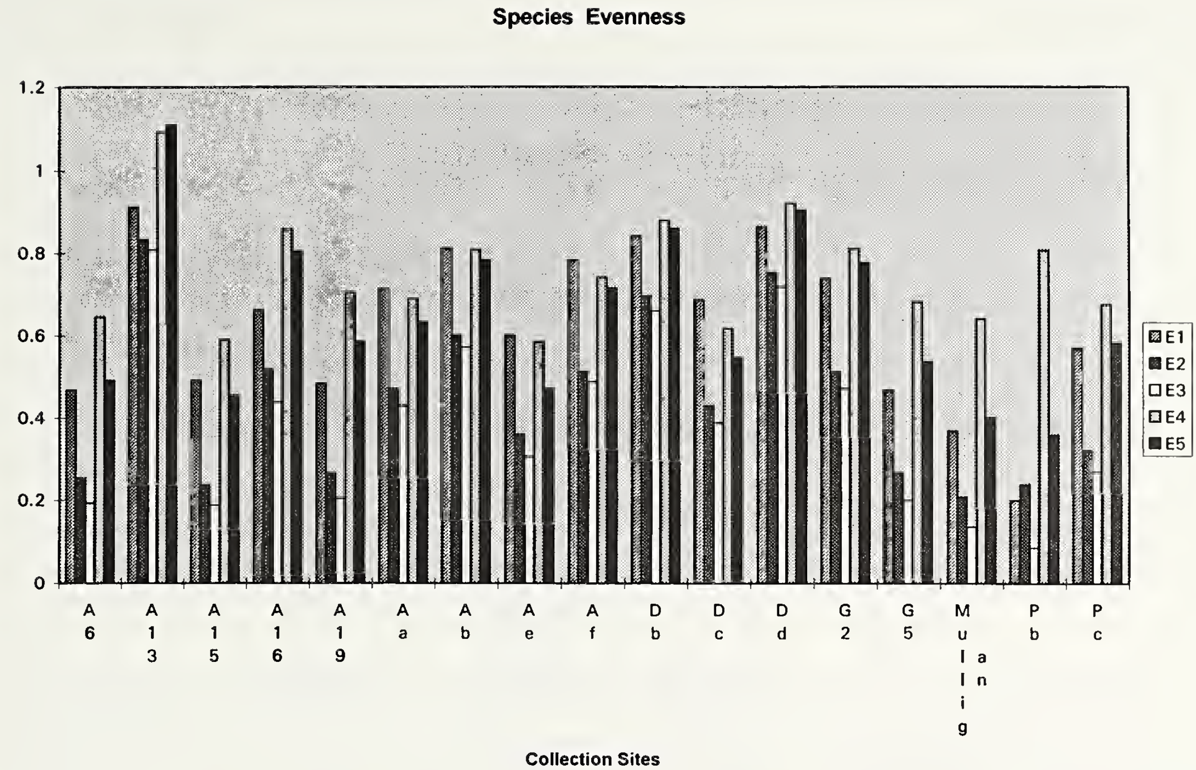

Figure 4. Relative species evenness by waterways, 1993-1994.

Table 2: Preliminary observations of fish reproduction at Fort Belvoir, 1993-1994, breeding= breeding colors or nuptial tubercles, gravid= female carrying eggs.

DATE	LOCATION	NOTES	TOTAL
	Rhinichthys atratulus		
02NOV92	A15	Gravid	4
02NOV92	A15	Breeding	2
08NOV92	A15	Gravid	1
08NOV92	A15	Breeding	2
20JAN93	A19	Breeding	2
25APR93	A13	Breeding	1
25APR93	A13	Gravid	1
20MAY93	A6	Breeding	57
20MAY93	A6	Gravid	21
22JUN93	G2	Gravid	2
22JUN93	G2	Breeding	4
25JUN93	G2	Breeding	24
15JUN93	G5	Breeding	11
15JUN93	G5	Gravid	11
31MAY93	G5	Gravid	25
31MAY93	G5	Breeding	2

Table 2. Continued

DATE	LOCATION	NOTES	TOTAL
	Lepomis macrochirus		
02NOV92	A15	Gravid	1
	Cyprinella spiloptera		
20JAN93	A19	Breeding	2
20MAY93	A6	Gravid	4
09JUL93	Af	Breeding	2
	Gambusia holbrooki		
22JUN93	G2	Gravid	2
09JUL93	Af	Gravid	1
	Semotilus atromaculatus		
08NOV92	A15	Gravid	1
20MAY93	A6	Gravid	3
20MAY93	A6	Breeding	2
26MAY93	A6	Gravid	10
26MAY93	A6	Breeding	7
25JUN93	G2	Gravid	1
15JUN93	G5	Gravid	9
	Fundulus diaphanus		
15JUN93	G5	Breeding	1
15JUN93	G5	Gravid	1
	Erimyzon oblongus		
20MAY93	A6	Breeding	2
22JUN93	G2	Breeding	2
25JUN93	G2	Breeding	1
15JUN93	G5	Breeding	2
	Clinostomus funduloides		
20MAY93	A6	Breeding	7
26MAY93	A6	Breeding	14
22JUN93	G2	Breeding	10
	Luxilus cornutus		
08NOV92	1A15	Breeding	1
20JAN93	1A19	Breeding	5
18MAY94	1Ae	Breeding	1

Table 2. Continued.

DATE	LOCATION	NOTES	TOTAL
	Hypentelium nigricans		
09JUL93	Af	Breeding	14
	Umbra pygmaea		
25APR93	A13	Breeding	1
	Fundulus heteroclitus		
15JUN93	G5	Breeding	4
15JUN93	G5	Gravid	5
	Notemigonus crysoleucas		
22JUN93	G02	Gravid	1
	Semotilus corporalis		
09JUL93	Af	Breeding	2
18MAY94	Ae	Breeding	1
	Notropis bifrenatus		
13JUL93	Ae	Breeding	2
	Catostomus commersoni		
12APR94	A19	Gravid	1
	Lepisosteus osseus		
12MAY93	Ab	Gravid	-
13MAY93	Ab	Gravid	-
14MAY93	Ab	Gravid	-
15MAY93	Ab	Gravid	-
16MAY93	Ab	Gravid	-
17MAY93	Ab	Gravid	-
18MAY93	Ab	Gravid	-
	Dorosoma cepedianum		
14Apr93	Mulligan	Gravid	-

FAMILY PETROMYZONTIDAE (Lampreys)

***Lampetra aepyptra* (Least Brook Lamprey).** This elongated, eel-like fish grows to a maximum TBL of 18 cm (Page and Burr 1991; 13 cm in Maryland, Seversmith 1953), and is a free-living, non-migratory member of a family containing several parasitic species. It has a circular, jawless mouth with several rows of small, clustered, conical teeth and two larger supraoral teeth (see Seversmith 1953 for a more detailed description). The mouth is narrower than the head when fully expanded. The muscular body has 52-60 trunk myomeres, and is tan to gray dorsally but cream to white beneath. The medial dorsal fin is divided, and the caudal fin is short and rounded. No paired lateral fins are present. Seven naked gill apertures lie on each side of the throat. Breeding adults become mottled with brown or dark gray, and develop a black edge on the dorsal fin, a black tip on the caudal fin, a black stripe extending through the eye, and a yellow stripe from the middle of the dorsal fin to the caudal fin. The male is more slender than the female, and has a long gonoducal papilla anterior to a reduced ventral fin (Seversmith 1953). Several larvae were captured while they were burrowing into the sand of collecting site G2, and another was taken as it attempted to burrow into the bank of a slow moving pool at site A15.

Spawning occurs in April and May when water temperatures rise to about 16° C (Jenkins and Burkhead 1994, Seversmith 1953). Over 1,000 eggs may be laid at one time in the fine gravel, silt or sandy bottom of a shallow, quiet pool or at pool-riffle interfaces. Adults apparently spawn and then die in their first year of maturity. Five to six years of growth are required before the ammocoetes larvae undergoes metamorphosis to the adult body form (Carlander 1969, Jenkins and Burkhead 1994, Lee et al. 1980). Transformation usually takes place in mid-August to late fall after a year of arrested growth. Adults apparently do not feed, as the digestive tract is reduced (Troutman 1957). The larvae are probably filter feeders.

Lampetra aepyptra is very sensitive to siltation and pollution, and disappears quickly if its stream becomes degraded (Clay 1975, Troutman 1957). A fairly large population of this small lamprey exists at Fort Belvoir, and, since Jenkins and Burkhead (1994) suggest it is declining in Virginia and should be protected, it should be monitored on the installation.

***Petromyzon marinus* (Sea or Marine Lamprey).** The USNM has two specimens of *Petromyzon marinus* (270983, 284124; fide Jeffrey Clayton) collected 4 June 1932 by F. M. Uhler and A. L. Nelson, with the associated locality data "Accotink Creek, VA". It is not known where on the creek these lampreys were taken, but, irregardless, they had to have passed upstream through Fort Belvoir from the Potomac River and Chesapeake Bay. Adults live in the Atlantic Ocean, but spawn in the gravel riffles of freshwater streams (anadromy).

The sea lamprey can be distinguished from its freshwater relative *Lampetra aepyptera*, the only other lamprey inhabiting northern Virginia, by the following suite of characters: 1) its larger size, TBL to 120 cm (Page and Burr 1991) (one of the USNM specimens is 57 cm long); 2) its coloration and pattern of dark mottled spots or small blotches on grayish to olive-brown back and sides and a cream to white venter; 3) 66-75 trunk myomeres; and 4) broad oral disc wider than the head when opened with two supraoral teeth, several lateral circumoral teeth, and an infraoral tooth-like plate. Breeding adults have olive to yellow-orange backs and sides and white venters. The spawning male also has a prominent ridge on its neck.

Adult *P. marinus* living along the Atlantic Coast make spawning runs, mostly at night, in March to July (Carlander 1969). They do not feed during the migration, and die shortly after spawning. A female may produce 13,000 to over 200,000 eggs, but probably the average is closer to 61,000

(Applegate 1950, 1951; Carlander 1969). These are laid in depressions cleared by the male in the gravel bottom. During spawning the male holds onto the female's head with his mouth and wraps his body around hers. After oviposition and fertilization both adults thrash about to stir up a cloud of gravel and silt to cover the eggs. The blind, toothless ammocoetes larvae hatch in 13-14 days, and then spend 4-7 years in the spawning stream before transformation. Once metamorphosed the subadults migrate downstream via the Chesapeake Bay to the ocean in January or February (Howell 1966). An additional year is needed before they are fully mature.

Only the larvae and subadults feed in freshwater. The ammocoetes are free living and apparently filter algae, diatoms and organic debris from the water (Cooper 1983). Subadults and adults are predaceous on a variety of fish. They attach to the side of a fish with their large, sucker-like mouth and use the teeth on their rough tongue to scrape a hole in the fish's flesh (Applegate 1950). Lymph and blood seeping from the wound are swallowed, aided by anticoagulants in the lamprey's saliva (Applegate 1950, Werner 1980). Fish eggs are also sometimes consumed by adults (Hildebrand and Schroeder 1972).

FAMILY LEPISOSTEIDAE (Gars)

Lepisosteus osseus **(Longnose Gar).** Longnose gars are easily identified by their very long, slender snouts with externally visible teeth, at least anteriorly; elongated bodies with the dorsal and anal fins set very near the rounded caudal fin; and armor-like ganoid body scales. There are 57-63 lateral scales. *Lepisosteus osseus* is olive to brown dorsally, cream to yellow ventrally, and has dark spots on the dorsal, caudal and anal fins. It may grow to 1.8 m TBL (Page and Burr 1991), but most adults at Fort Belvoir are about 1.0 m long. Juveniles have a narrow brown dorsal stripe, a wider brown or black lateral stripe, and a blackish venter.

This is the only gar in the region, and according to Kelso (1992) its population is declining. In the vicinity of Fort Belvoir it is mostly found in the tidal portions of the Potomac River, and is still fairly common in Gunston Cove. *Lepisosteus osseus* enters, at least, Accotink Creek to spawn.

Longnose gar were observed spawning on 17-18 May 1993 in Accotink Creek below the U.S. Route 1 bridge, with several males accompanying each female. A female may produce over 77,000 eggs per season (Carlander 1969) which are laid over a broad expanse of the bottom in shallow water, where they adhere to rocks, logs, vegetation, and other submerged objects. This species neither constructs a nest nor shows any parental care of the eggs or young. The eggs are relatively large (about 4 mm in diameter; Cook 1959), and are poisonous to humans if swallowed.

Recently hatched *L. osseus* feed primarily on insect larvae and small crustaceans, but become more piscivorous as they grow; adults eat mostly fish, but occasionally consume crabs (Carlander 1969, Lee et al. 1980).

FAMILY CLUPEIDAE (Herrings and Shads)

Dorosoma cepedianum **(Gizzard Shad).** Dead adult gizzard shad were found on 14 April, 1993 floating in Mulligans Pond, and others were collected at sites Aa and Dc in spring 1994. The species is tolerant of brackish conditions, and is most commonly found in the deeper waters of Gunston Cove and the Potomac River, but schools make spring spawning runs up tributary streams, such as Dogue Creek into which Mulligans Pond drains. Apparently they entered the pond during such a run.

Dorosoma cepedianum is easily identified by its laterally compressed body, silvery color, very long last dorsal ray, dark spot on the shoulder (lost in some adults), serrated row of scales along the

midline of the chest and abdomen, and long anal fin with 25-36 rays. Its snout is bluntly rounded, the caudal fin is deeply forked, and 52-70 lateral scales are present. Adults may grow to 52 cm TBL (Page and Burr 1991), but most individuals are under 35 cm long.

Spawning occurs in April and May, usually at night after water temperatures have risen above 16° C, in water levels of less than 1.5 m (Williamson and Nelson 1985). A female may produce up to 540,000 eggs (Carlander 1969). Normally, heavy post-spawning mortality occurs (Jenkins and Burkhead 1994), and this explains the dead gizzard shad seen at Fort Belvoir in April and May.

Primarily a plankton filter-feeder, typical foods of the gizzard shad are algae, diatoms, protozoans, microcrustaceans (cladocerans, copepods), rotifers, oligochaete worms, midge larvae, and detritus (Carlander 1969, Jenkins and Burkhead 1994, Lee et al. 1980, Williamson and Nelson 1985).

FAMILY ANGUILLIDAE (Freshwater Eels)

***Anguilla rostrata* (American Eel).** This is the "slimy eel" of most American freshwater fishermen, and the only member of its family found on the continent. It is a catadromous species that spends most of the developmental years until maturity in the tidal and freshwater portions of streams and rivers. Only females venture far above the tidal zone (Carlander 1969). Normally this takes 10-15 years, but maturity may be reached in as little as five or as long as 25 years. After maturing, adults perform a long autumn migration from freshwater to the south-central Atlantic Ocean, possibly in the area of the Sargasso Sea. There they spawn in the winter at depths of 400-500 m (Lee et al. 1980).

A female may carry over 10 million eggs. The eggs hatch into small leptocephalus larvae which begin a one year migration back to the freshwaters of North America. Metamorphosis in freshwater includes the following stages: 1) the glass-eel stage, in which the small larva is transparent but has all adult morphological characters; 2) the elver stage, in which the small larva develops dark body pigment; and 3) the juvenile stage, when it grows to adult size. Growth may be very rapid.

This is one of the easiest fishes to identify. It has a long, slender muscular body (TBL to 1.52 m, Page and Burr 1991; but most adults are probably less than a meter long); a pointed head; relatively large, oblique mouth; no pelvic fins; enlarged pectoral fins; continuous dorsal, caudal and anal fins; the opercular margin partly fused to the body leaving only a small gill aperture; and extremely small, barely visible cycloid scales. The skin contains numerous mucous glands which can quickly secrete a slimy coat over the entire body surface, making the fish very hard to grasp. Body color of juveniles ranges from yellow-brown to olive-brown, with a lighter venter. Mature individuals are olive-black dorsally but silvery along the sides and venter.

Anguilla rostrata is most often found in permanent streams with abundant cover of logs, rocks, undercut banks, or aquatic weed beds. The bottom may be either soft (mud or sand) or rocky, and it often buries itself partially or totally in the stream bed. Carlander (1969) reported it can withstand water temperatures up to 35° C. Fort Belvoir records are from all collecting sites, except Aa and the INSCOM Pond. Most activity is nocturnal, and American eels have been found crawling overland on wet nights.

Anguilla rostrata is predominately carnivorous, feeding chiefly at night (Jenkins and Burkhead 1994). Its principal prey is annelid worms, insects, crayfish, amphipods, isopods, snails, clams, tunicates, small fish (both alive and dead), frogs and tadpoles (Carlander 1969, Cooper 1983, Hildebrand and Schroeder 1972, Jenkins and Burkhead 1994, Troutman 1957). Troutman reported this fish also eats "garbage."

FAMILY UMBRIDAE (Mudminnows)

***Umbra pygmaea* (Eastern Mudminnow).** The eastern mudminnow is the only member of its family living in the region. As the common name implies, it dwells in quiet, soft-bottom waterways with patches of aquatic vegetation, such as sloughs, drainage ditches, swamps, and slow moving streams. Often it is found in extremely warm, shallow habitats with low oxygen, and it may even burrow into the soft bottom substrate until completely hidden (Ernst pers. obs.). At Fort Belvoir it was often collected at sites vernally separated from main creek channels: A6, A13, Dc, G2, G5, and Mulligans Pond.

Umbra pygmaea grows to 11 cm TBL (Page and Burr 1991), is olive-green, with a blunt snout, a rounded (unnotched) caudal fin, the single dorsal fin set well posterior, a black bar (sometimes broken into 2-3 spots) at the base of the tail, 10-14 dark stripes extending along its sides, and 30-37 scales along the lateral line. Breeding males develop iridescent bluish pigment on the pelvic and anal fins.

Very little is known of the behavior of this fish. Spawning probably occurs in March and April at water temperatures of 10-15° C. A male in breeding color was collected at site A13b on 25 April. Ryder (1886) reported the females attach adhesive eggs individually to aquatic plants or in cavities in algal mats.

A nocturnal feeder, the food of the eastern mudminnow consists of amphipods, copepods, isopods, ostracods, small crayfish, dipteran larvae, trichopterans, snails, and, rarely, small fish (Carlander 1969, Flemer and Woolcott 1966, Jenkins and Burkhead 1994).

FAMILY ICTALURIDAE (Bullhead Catfish)

***Ameiurus natalis* (Yellow Bullhead).** Bullhead catfish have unpatterned bodies and straight, unnotched, caudal fins. *Ameiurus natalis* is easily identified by its white, cream or yellow chin barbels. It also has a long anal fin with 23-28 rays and, often, a dark pigmented band, and 5-8 large serrations on the posterior edge of its pectoral spine. The back is olive-yellow to dark gray or brown, the sides are yellow to olive-yellow, and the venter is white to yellow. It may grow to a maximum TBL of 47 cm (Page and Burr 1991).

Typically a resident of sluggish waters (often of low oxygen content) with soft bottoms, and aquatic weed beds, such as ponds, shallow impoundments, and pools in streams. *Ameiurus natalis* was recorded from Mulligans Pond (Morton et al. 1991), and collected at sites Ab, Dc, and Dd. It is not known whether it was stocked in Mulligans Pond or had entered via the small connection with Dogue Creek. The species is native to northern Virginia.

Spawning occurs in shallow streams during May and June (Ernst pers. obs.), but little else is known of the yellow bullhead's reproductive habits in northern Virginia. Carlander (1969) reported that females may carry 1,652 to 6,660 eggs. Males excavate a depression in the soft bottom or in the bank of a shallow stream and guard the sticky mass of eggs laid there by females, and later the newly hatched fry (Cook 1959, Cooper 1983).

Yellow bullheads subsist on oligochaete worms, small crustaceans, crayfish, beetles, mayfly nymphs, and small fish (Carlander 1969, Flemer and Woolcott 1966).

***Ameiurus nebulosus* (Brown Bullhead).** This is the common bullhead of the region. It can be distinguished from *A. natalis* by its dark brown or black chin barbels. Its back is dark gray, olive or brown with some dark mottling, and the venter is white or yellowish. The anal fin is relatively short

with only 18-30 rays, and the pectoral spine has 5-8 large serrations on its posterior edge. No dark pigment is present on the caudal or anal fins. Although the brown bullhead may grow to 50 cm TBL (Page and Burr 1991), most adults are probably 20-30 cm.

The brown bullhead is usually found in moderately clear, slow moving, soft-bottomed waterways, such as lakes, impoundments, ponds, swamps, canals, oxbows, and the pools of sluggish streams. It has been taken from the INSCOM Pond (Morton et al. 1991) and at stream sites A19, Ae, Af, Db, Dc, G5, and Pc, and it is common in Gunston Cove (Morgan pers. obs.). A portion of the winter may be spent buried in the soft bottom (Carlander 1969, Werner 1980).

Most spawning in northern Virginia occurs in shallow water during May and June after water temperatures reach 20° C. The male clears a nest depression, often near a sunken log, and both parents care for the schools of small black fry (Blumer 1988, Emig 1966, Ernst pers. obs.). A female may produce 2,000 to 13,800 eggs each year (Carlander 1969), and spawn more than once a season (Werner 1980).

Ameiurus nebulosus is a nocturnal feeder that uses its barbels to detect prey. Food consumed includes blue-green cyanobacteria, filamentous algae, oligochaete worms, earthworms, snails, clams, copepods, cladocerans, ostracods, amphipods, isopods, crayfish, beetles, dipteran larvae, dobsonfly larvae, mayfly nymphs, and small fish (Carlander 1969, Clay 1975, Cooper 1983, Flemer and Woolcott 1966, Keast 1985, Lohr 1992, Raney and Webster 1940).

***Ictalurus punctatus* (Channel Catfish).** The large, introduced channel catfish may grow to a TBL of 127 cm (Page and Burr 1991). It is easily distinguished from the other catfish of the region by its forked caudal fin, spotted body pattern, and dark chin barbels. Its back and sides are bluish-gray with scattered small dark spots, and the venter is white. Breeding males are darker and have broader heads than females; also, in females the genital and urinary pores are separate while in males they are united into a single urinogenital pore (Moen 1959).

Ictalurus punctatus is typically found in the deep waters of lakes or rivers with sand or gravel bottoms, but, since it is a popular panfish, it has been stocked in many ponds and impoundments in northern Virginia, such as the INSCOM Pond at Fort Belvoir (Morton et al. 1991). It is common in the main channel of the Potomac River (Ernst pers. obs.), but was not taken in any of the installation's streams.

Having been so long a popular commercial fish, extensive literature exists on *I. punctatus*, particularly concerning culturing techniques (see Carlander 1969 for a review). In northern Virginia, most spawning takes place in June or July after water temperatures reach 24° C (Ernst pers. obs.). Probably females mate twice a season, and produce about 2,000 to 70,000 eggs a year (Carlander 1969). Spawning behavior is similar to that of the brown bullhead, *A. nebulosus* (Ernst pers. obs.), but holes and animal burrows in banks or hollow logs may also be used as egg-laying sites (Cook 1959, Cross 1967).

Primarily a crepuscular (dusk and dawn) or nocturnal feeder, the diet of the channel catfish consists of filamentous algae, plant debris, seeds, hydroids, oligochaete worms, earthworms, snails, clams, small bottom crustaceans, crayfish, caddisflies, mayfly nymphs, and other aquatic insects, small fish, and occasionally prey as large as birds or small mammals may be ingested (Carlander 1969, Cooper 1983, Jenkins and Burkhead 1994).

FAMILY CYPRINIDAE (Carps, Minnows, Daces & Shiners)

Carassius auratus **(Goldfish).** This Asian minnow was introduced into the Washington, D. C. area as a novelty fish, and, because of captive and bait fish releases or its being washed out of flooded fish ponds, the goldfish is now widespread in this portion of the Potomac River watershed. *Carassius auratus* is tolerant of low oxygen and polluted conditions. Typical habitats in the region are warm (to 36-38° C), soft-bottomed, sluggish waterbodies with thick vegetation, such as the many tidal marshes along the Potomac River. It was collected at sites Db, Dc, G5 and Pc.

The goldfish has a deep body with large scales, an upturned mouth, a long dorsal fin with 15-18 rays, a notched caudal fin, and a decurved lateral line covering 28-32 scales. Heavy spines adorn the front of both the dorsal and anal fins. The back and sides vary in color from reddish-orange to brown or olive-gray, and some individuals may be red and white blotched; the venter is usually white. The species may grow to 41 cm TBL (Page and Burr 1991).

We have observed no reproductive behavior at Fort Belvoir. Elsewhere *C. auratus* is a May-July breeder, usually at water temperatures above 20° C (Carlander 1969). The 2,000 to 4,000 adhesive eggs are deposited on floating vegetation or submerged plants (Cook 1959, Cooper 1983, Jenkins and Burkhead 1994). Apparently no parental care is shown either the eggs or fry. The goldfish is an omnivore which feeds particularly on phytoplankton, but it also takes zooplankton and insect larvae (Carlander 1969, Cooper 1983, Lee et al. 1980).

Clinostomus funduloides **(Rosyside Dace).** The common name of this small cyprinid (TBL to 11 cm, Page and Burr 1991) refers to the bright red pigmentation on the lower sides of the mature male during the breeding season. Breeding males also develop bluish-gray backs and small tubercles on the head, body and fins. Nonbreeding males, females and juveniles have a olive back, a black stripe extending from the snout to the tail (but somewhat faded behind the operculum), a yellowish stripe above the dark stripe, a white to orangish-red lower side, a large forked tail, a long pointed snout, and a large oblique mouth. No pigmentation is present on the fins. The anal fin has 8-9 rays, and 43-60 scales lie along the downward curved lateral line. The subspecies in northern Virginia is *Clinostomus funduloides funduloides*. A common inhabitant of pools in clear streams, this species was collected at sites A6, A15, G2 and G5.

Spawning occurs in riffles during May and June at water temperatures above 13° C. Breeding activity was recorded at Fort Belvoir from 20 May to 22 June. Females may lay 139 to 802 eggs (Carlander 1969). The male prepares no nest (but may use those of *Semotilus atromaculatus*), and provides no parental care for the eggs (Cooper 1983).

Normal prey consists of insects (adult and larval dipterans, beetles, ants, thysanopterans, trichopterans), copepods, crayfish, arachnids, worms, snails, diatoms and filamentous algae. (Flemer and Woolcott 1966, Jenkins and Burkhead 1994).

Cyprinella analostana **(Satinfin Shiner).** This small cyprinid (TBL to 11 cm; Brooks and Burr 1991) is similar in appearance to the spotfin shiner, *C. spiloptera*, but can be distinguished by its nine anal fin rays (eight in *C. spiloptera*), 33-38 lateral line scales, and blackish spots on all membranes of the dorsal fin. It is deep-bodied with a relatively long snout and terminal mouth. The back and sides are olivaceous, the venter white, and a dusky stripe extends along the posterior side of the body. The fins are often yellowish. *Cyprinella analostana* has been recorded from Accotink Creek at U.S. Route 1 (USNM 100151, 10+ individuals). This species is usually found in the shallows and pools of medium to large piedmont or upland streams with sand, gravel, or rocky bottoms.

Spawning is in May to August at water temperatures of 18-27° C (Carlander 1969, Lee et al. 1980). Females produce 300 to 3,600 eggs per season, and probably spawn twice a year (Jenkins and

Burkhead 1994). Males display territorial possession of the spawning site, but give no care to the eggs or fry. The eggs are laid in crevices in the bark of submerged logs or in cracks in rocks (Cooper 1983).

Cyprinella analostana is almost entirely insectivorous, feeding primarily on the larvae or nymphs of caddisflies, dipterans, mayflies, plecopterans, and trichopterans (Carlander 1969, Cooper 1983, Flemer and Woolcott 1966), but microcrustaceans are also eaten (Jenkins and Burkhead 1994).

***Cyprinella spiloptera* (Spotfin Shiner).** This plain, silver-gray minnow is best identified by the black spot on the lower posterior portion of its dorsal fin. Other important characters are a pointed snout, terminal mouth, forked caudal fin, eight anal fin rays, black dorsal stripe, dusky posterior lateral stripe, slightly decurved lateral line along 34-41 scales, and a white breast. Maximum TBL is 12 cm (Page and Burr 1991). Breeding males become darker gray with yellow fins, and develop numerous tubercles on their snouts. The black blotch on the dorsal fin also enlarges and darkens.

The spotfin shiner is found in pools and shallow riffles of small unvegetated creeks and their tributaries. At Fort Belvoir it has been taken in the Accotink Creek watershed at sites A6, A13, A15, A16, A19, Ab, and Af.

According to Carlander (1969), spawning begins in June and continues until August, but gravid females were noted at Fort Belvoir as early as 20 May and a male in breeding color was captured in January. Males vocalize and defend territories about logs (Winn and Stout 1960). Carlander (1969) reported a probable females mate twice each season. The female attaches clusters of eggs to the undersides, or in crevices of submerged branches or logs. A female may produce over 7,000 eggs a season.

Most feeding is done at mid-water depths. Algae, seeds, small insects (usually terrestrial), crayfish, and microcrustaceans are the primary food items (Carlander 1969, Cooper 1983, Jenkins and Burkhead 1994, Lee et al. 1980).

***Cyprinus carpio* (Common Carp).** The carp, a native of Asia, was introduced into Europe in the thirteenth century (Cook 1959) and raised as a commercial species. It was first brought to North America in 1831 (Page and Burr 1991), and was later so widely stocked by the U.S. Fish Commission (Cooper 1983) that it became the most common nuisance fish in the United States. A bottom feeder, *C. carpio* occurs in its greatest abundance in sluggish, weedy waterways with highly organic soft bottoms, particularly impoundments and ponds. It has been recorded from Mulligans Pond by Morton et al. (1991), and two were collected at site Ae in 1994. Its scarcity at Fort Belvoir is odd, since this fish is wide-spread and common in other watersheds and impoundments in northern Virginia.

The carp is the largest cyprinid of the region, growing to a record 122 cm TBL (Page and Burr 1991) and 27 kg in North America (Carlander 1969), although most adults are about half this length and weight. There are 32-38 scales along the lateral line. The back is silvery-gray to greenish-gray or brownish with dark-bordered scales. The fins may contain some grayish pigment, and become reddish-orange during the breeding season. The body is deepest anterior to the long dorsal fin (16-23 rays, three spines). The caudal fin is moderately forked, and the anal fin has 5-6 rays and three spines. Two barbels are present on each upper jaw, with the posterior the longest.

Spring spawning starts when the water temperature is 14.5-17.0° C, but is most active at 18.5-22.0° C (Carlander 1969, Jenkins and Burkhead 1994). The spawning season in northern Virginia usually lasts from late May to June or July (Ernst pers. obs.). During this period each female probably spawns twice (Carlander 1969). Several males may court one female, with much splashing, in the shallows of the major streams flowing through Ft. Belvoir. The eggs are scattered at random over plant

beds, gravel or debris, to which they adhere in clumps. A female may produce over two million eggs per season, but normally less than half this number, and 80% of the eggs are probably laid during the first spawning (Carlander 1969). No parental care is shown to either the eggs or fry.

Young carp feed on small planktonic organisms (algae, diatoms, daphnia, rotifers), but gradually take larger prey until, as adults, they live primarily on parts of aquatic plants, but also take tubifex and oligochaete worms, small clams, various insect larvae and nymphs, and even small fish (Carlander 1969, Clay 1975, Cook 1959, Cooper 1983, Hildebrand and Schroeder 1972, Jenkins and Burkhead 1994, Ernst pers. obs.).

Exoglossum maxillingua **(Cutlips Minnow).** Best identified by the unique configuration of its mouth, which has two prominent fleshy lateral lobes on the lower lip, the cutlips minnow is a thick-bodied (TBL to 16 cm; Page and Burr 1991), brownish-gray to olive-gray fish with a dark head, faded lateral stripe (at least in the young), dark caudal spot (often only in the young), and white venter. The dorsal fin begins directly above the origin of the pelvic fin, the anal fin has seven rays, the caudal fin is shallowly notched, and 46-53 scales are present in the lateral line. Males are larger and more chubby-bodied than females. Normally this fish is found in rocky or gravel-bottomed reaches of clear medium to large creeks with moderate current. It was collected only at sites Ae and Pc.

Cutlips minnows spawn in May at water temperatures of 17-22° C. Males build a stone nest by moving pebbles into a flat-topped mound 7.5-15 cm high, and covering a diameter of 30-45 cm (Van Duzer 1939). While spawning the adults lie together at the upstream edge of the nest, and the female deposits the semiadhesive eggs in the gravel. The male guards the eggs until they hatch, and then the newly hatched larvae for about seven additional days.

The diet of *E. maxillingua* consists of algae, plant debris, small snails and clams, bottom dwelling insects (dipteran larvae, mayfly nymphs, trichopteran larvae), worms, crayfish, fish eggs, and the ammocoetes larvae of lampreys (Carlander 1969, Cooper 1983, Jenkins and Burkhead 1994, Lee et al. 1980). The cutlips minnow is known for its habit of plucking out the eyes of other fishes with its sucker-like lips (Jenkins and Burkhead 1994, Page and Burr 1991).

Hybognathus regius **(Eastern Silvery Minnow).** This common stout-bodied cyprinid may grow to a 12 cm TBL (Page and Burr 1991). It has a dark olive-brown back and silvery sides. A faded dark stripe extends along the side. The dorsal fin is pointed, the caudal fin is deeply forked, and the mouth is slightly upturned.

Hybognathus regius prefers the quiet waters of pools in medium to large streams: sites A15, A19, Aa, Ab, and Dc.

The spawning season covers late April and the first half of May, when water temperatures climb above 13° C (Lee et al. 1980). The fish gather in schools where several males spawn with a single female (Cooper 1983, Raney 1939). Females scatter their eggs over decaying vegetation in calm waters with low siltation. The eggs receive no parental care (Raney 1939).

Lee et al. (1980) reported that algae and bottom ooze seem to be the main foods, but Cooper (1983) thought the prey consists of a variety of plants and animals ranging from diatoms to small insects. Flemer and Woolcott (1966) found that microscopic items, such as diatoms, desmids, and filamentous algae, comprised about 41% of the diet in a tributary of the James River in Henrico and Goochland Counties, Virginia.

***Luxilus cornutus* (Common Shiner).** Because this fish lacks many distinct characters, it is often difficult to identify with certainty. It is a large, stout-bodied minnow that may reach a TBL of 18 cm (Page and Burr 1991). The body is olive-brown dorsally, silver, white or cream ventrally, and usually has three dark longitudinal stripes along the back. The medial stripe is widest and most pronounced. Unlike many other minnows in the region, *L. cornutus* lacks a lateral stripe. Scales on the sides and back often flake off and appear loose; 30-35 scales occur around the body just in front of the dorsal fin. The lateral line covers 36-43 scales. Juveniles do not develop scales until the fall after hatching. The dorsal fin begins slightly anterior to the origin of the pelvic fin; the anal fin has nine rays. Breeding males (and occasionally females) become pinkish with reddish pigment on the fins. Males may develop tubercles on the head and snout during the spawning season.

As the common name implies, *L. cornutus* normally occurs in large numbers in small to medium-sized, clear, often shaded streams with alternating pools and gravel riffles. In addition to the capture sites recorded in this study (A15, A19, Aa, Ab, Db, Pc), a Fort Belvoir' specimen in the USNM (100150) is from Accotink Creek at the U. S. Route 1 bridge.

Spawning begins in gravel riffles after spring water temperatures climb to 19-21° C (Carlander 1969, Raney 1940), but males in apparent breeding condition were noted in November and January. Males are territorial. Some construct a slight cleared depression by fanning away the gravel, but others merely use the nests of other cyprinids, such as the creek chub, *Semotilus atromaculatus*. Females usually lay about 50 eggs in a nest, but may carry over 1,000 eggs, so several matings per season probably occur (Carlander 1969, Raney 1940, Werner 1980).

Food includes algae (desmids, diatoms, filamentous), aquatic plants, rotifers, spiders, and insects (adult and larval dipterans, beetles, mayflies, hemipterans, hymenopterans, dragonflies, trichopterans), and small fish (Carlander 1969, Flemer and Woolcott 1966, Jenkins and Burkhead 1994, Werner 1980).

The common shiner is often used as a bait fish, and escaped or released individuals have confused the distribution of the species. Also confusing the issue is its practice of hybridizing with other cyprinids (Carlander 1969, Cooper 1983).

***Nocomis micropogon* (River Chub).** This is a long-snouted, largemouthed, small-eyed cyprinid with a prominent barbel in each corner of its mouth. The body is olive to olive-brown dorsally, greenish-yellow along the sides, and white to cream ventrally. The dorsal scales are often outlined with black pigment, a faded lateral stripe may be present, and a black bar lies behind the operculum. A faded separate dark spot may be present at the base of the caudal fin, or it may join the lateral stripe. Often, another dark spot is present on the anterior base of the dorsal fin. The fins may be reddish-orange. The lateral line contains 37-43 scales, and the species may reach a TBL of 32 cm (Page and Burr 1991). Breeding males develop bluish-gray pigment on their heads, body and fins, nuptial tubercles on the snout, and a prominent forehead lump. The subspecies in northern Virginia is *Nocomis micropogon micropogon*.

Typical habitats are the rocky or gravely pools and riffles of small to medium-sized, clean streams, and *N. micropogon* was recorded only from the main channel of Accotink Creek at site Af.

Spawning is in May and June at Fort Belvoir at water temperatures above 20° C. Spawning sites are in shallow water where the male constructs a nest mound of pebbles carried there individually in its mouth (Carlander 1969, Miller 1964, Ernst pers. obs.). The nests may be 40-60 cm in diameter. The male defends the nest mound, and he may mate with several females a season.

Young river chubs feed primarily on small crustaceans (cladocerans, ostracods), bottom dwelling insects (blackfly larvae, chironomids, mayfly nymphs), while adults add small clams, snails and crayfish to this diet (Carlander 1969, Cooper 1983, Lee et al. 1980, Ernst pers. obs.).

***Notemigonus crysoleucas* (Golden Shiner).** A breeding male golden shiner is one of the more beautiful fishes at Fort Belvoir, with its golden back and sides, white venter, and orange-red anal fin. Its other fins may also be yellowish. Females have olivaceous to silvery-gold backs and sides and white to silvery venters. The body is laterally compressed, and may grow to 30 cm TBL (Page and Burr 1991). The lateral line covers 43-56 scales and is decurved. The dorsal fin begins posterior to the origin of the of the pelvic fin, the anal fin has 11-14 rays. A naked (scaleless) ventral keel is present between the pelvic and anal fins, and the mouth is upturned.

Normally a resident of well vegetated, slow flowing, soft-bottomed waterways, *N. crysoleucas* can survive in waters as warm as 35° C (Carlander 1969). It was recorded at sites Aa, Af, Dc, Dd, G2, and at Mulligans Pond.

A gravid female was collected at site G2b on 22 June. Elsewhere in its range the golden shiner's mating season lasts from April to October, usually at water temperatures of at least 20-21° C (Carlander 1969, Jenkins and Burkhead 1994). Females may spawn at least twice a season. No nest is constructed, the adhesive eggs are merely scattered over aquatic vegetation and abandoned (Werner 1980).

Notemigonus crysoleucas often feeds in large schools at the surface or at midwater level. Much of the diet consists of algae, amphipods, cladocerans, copepods, arachnids, insects (beetles, dipteran larvae, hemipterans, hymenopterans), snails, and small clams (Carlander 1969, Flemer and Woolcott 1966, Hildebrand and Schroeder 1972, Jenkins and Burkhead 1994). Golden shiners from a piedmont tributary of the James River, Virginia contained primarily phytoplankton (37%) and insects (21%) (Flemer and Woolcott 1966).

***Notropis bifrenatus* (Bridle Shiner).** One of the region's smallest cyprinids, the bridle shiner only grows to a maximum TBL of 6.5 cm (Page and Burr 1991), and has a pointed snout and a small oblique mouth. It is olive-yellow or olive-brown above with strikingly dark-bordered scales, cream to white below, and has a dark head and yellowish fins. A dark stripe extends from the snout to the base of the deeply notched caudal fin where it meets a well defined dark spot. A dark middorsal stripe is present, but no dark pigment occurs on the dorsal fin. The anal fin has seven rays, and 31-37 scales occur along the slightly decurved lateral line. Breeding males are brightly-colored with a well developed lateral stripe, while breeding females are dark gray with a more poorly defined lateral stripe and deeper bodied. *Notropis bifrenatus* prefers slow-flowing mud or sand-bottom creeks, and apparently shuns brackish water (Hildebrand and Schroeder 1972). It was found only at sites Ae and Af.

Breeding males were collected at site Ae9 on 13 July. Most spawning occurs in May and June in slow moving, shallow water, usually among clumps of aquatic vegetation (Harrington 1947). Females produce 300 to 2100 eggs per season, depending on their body size (Carlander 1969). No nest is built, nor are the eggs or fry protected.

Notropis bifrenatus gleans small insects and crustaceans from the bottom or plant surfaces (Cooper 1983, Harrington 1948). All stomachs examined by Hildebrand and Schroeder (1972) contained vegetable matter, ranging from algae to parts of vascular plants.

Burkhead and Jenkins (1991) and Jenkins and Burkhead (1994) recommended that *N. bifrenatus* be named a Species of Special Concern by the Commonwealth of Virginia. Despite its apparent rarity

elsewhere in Virginia, *N. bifrenatus* was found to be the dominant fish at site Ae, and the most common cyprinid at site Af.

***Notropis hudsonius* (Spottail Shiner).** This small cyprinid (TBL to 15 cm, Page and Burr 1991) is very similar to the bridle shiner, *N. bifrenatus*, in having an olive-brown or grayish-yellow dorsum with black-bordered scales, and a faded lateral stripe. However, its large black tail spot is usually separated from the lateral stripe, whereas that of *N. bifrenatus* touches the lateral stripe. The eyes of *N. hudsonius* are also proportionately larger. It has 34-42 lateral line scales and eight anal fin rays. Breeding males develop tubercles on their snouts. The subspecies in northern Virginia is *Notropis hudsonius amarus*.

At Fort Belvoir *N. hudsonius* has been taken at sites A19, Aa, Db, Pb and Pc. Preferred habitats are sandy or gravel-bottomed stretches of medium to large, often deep, streams and rivers or the shores of lakes or impoundments to depths of 18 m. Clear water is required, and it can withstand temperatures as high as 35° C for at least short periods (Carlander 1969).

The breeding season in northern Virginia includes June, and possibly early July. Females may produce over 4,000 eggs per season, and release these over algae beds or sand bars (Wells and House 1974). No parental care is given to the eggs.

Small spottail shiners live on algae, rotifers, water mites and other small crustaceans, and possibly fish eggs; adults feed mainly on cladocerans, insect larvae, small mollusks, and fish larvae (Carlander 1969, Wells and House 1974).

***Notropis procne* (Swallowtail Shiner).** Characteristics identifying this cyprinid include a slender, fairly compressed body, deeply forked caudal fin, seven anal fin rays, slightly decurved lateral line (at least anteriorly) along 30-38 scales, relatively blunt snout, subterminal mouth, and dark (sometimes faded anteriorly) stripe along the side of the body. Maximum TBL is 7.6 cm (Carlander 1969). The body is silver to yellowish dorsally, but more whitish ventrally. Breeding males have yellow bodies and fins. Most often *N. procne* inhabits warm, sandy or gravel bottomed creeks or brooks, and it was found at sites A6, Aa, Ab, Ae, Af, and Pc. The subspecies present at Ft. Belvoir is *Notropis procne longiceps*.

Little has been reported concerning the life history of this species. It spawns from mid-May to July in shallow riffles over fine gravel or sand at water temperatures over 20 C (Jenkins and Burkhead 1994, Raney 1947). Males seem territorial during this period, but do not establish or defend a nest (Cooper 1983). Only a few eggs are laid at a time, and these are scattered over the bottom.

Notropis procne subsists on various worms, microcrustaceans, mites, aquatic insects, diatoms, and filamentous algae (Breder and Crawford 1922, Cooper 1983, Jenkins and Burkhead 1994).

***Pimephales notatus* (Bluntnose Minnow).** The genus *Pimephales* can be distinguished from other cyprinid genera occurring in the region by the membrane that separates the first fully formed ray of the dorsal fin from the half-formed ray in front of it. *Pimephales notatus* is a tan to olive-yellow, slender-bodied, blunt-nosed, flat-headed minnow with a prominent black spot at the base of its forked caudal fin, another on the anterior edge of the dorsal fin, a black stripe running from the snout to the tail, and a small subterminal mouth. The anal fin has seven rays, and 37-43 scales lie along the lateral line. TBL may reach 11.2 cm (Carlander 1969). The breeding male has a black head, a dark body, three rows of tubercles on its snout, a black bar through both the dorsal and caudal fins, and a light posterior border to the operculum. Breeding females often develop an orangish-brown streak along lower side. This fish is most commonly found in rocky or gravely streams and brooks. Individuals were recorded at A6, Af, and G2.

Spawning begins in late April or May after water temperatures have climbed to 20° C (Werner 1980), and continues into the summer. Spawning migrations may be made from streams to more shallow tributaries. A typical nest is a cavity scraped out by a male under a rock or sunken log where the female attaches the eggs to the undersurface. Two or more clutches of 200 to 500 eggs are produced by each female, and over 2,000 eggs have been found in a single nest (Carlander 1969). Females may spawn over 10 times a season (Jenkins and Burkhead 1994).

The diet consists of algae, organic detritus, worms, insect larvae, and fish eggs (Jenkins and Burkhead 1994, Lee et al. 1980).

***Rhinichthys atratulus* (Blacknose Dace).** This small minnow may grow to a TBL of 10 cm (Page and Burr 1991), but most captured at Fort Belvoir are smaller. It is light brown to olive-brown above and white below with numerous mottled dark spots on the back and sides. A black stripe begins on the snout and passes through the eye along the side to the tail. It may be interrupted along the trunk to form a series of black blotches. The snout only slightly overlaps the mouth, and a small barbel is present at the corner of the jaws. During the breeding season males develop reddish to yellowish pectoral and pelvic fins, orange to reddish pigment below the black side stripe, and pads on the dorsal surface of the pectoral fins. Fifty-three to 63 scales lie along the lateral line. The anal fin has seven rays. This small fish prefers gravel riffles and pools in brooks and creeks with some slope (A6, A13, A15, A16, A19, Ab, Ae, Af, G2, G5). The subspecies at Ft. Belvoir is *Rhinichthys atratulus atratulus*.

Normally spawning occurs from late April to June at Ft. Belvoir after water temperatures reach 22° C (Carlander 1969), but adults appeared in breeding condition from 2 November to 25 June. Males may be territorial, but they prepare no nest. Females lay over 700 eggs.

The blacknose dace's diet includes amphipods, isopods, spiders, mites, chironomids, mayfly nymphs, stonefly nymphs, oligochaete worms, larval fish, diatoms, filamentous algae, and plant debris (Carlander 1969, Cooper 1983, Jenkins and Burkhead 1994). In *R. atratulus* examined by Flemer and Woolcott (1966), microscopic plants and plant parts accounted for 64% of the diet, and the rest was mainly unidentifiable insect parts and larvae.

***Rhinichthys cataractae* (Longnose Dace).** *Rhinichthys cataractae* is a bottom-dwelling resident of the upper portions of major creeks flowing through Fort Belvoir. Typical habitat is a shallow, rocky or gravel-bottomed riffle or pool in a small to medium creek with moderate to fast current under abundant overhead canopy. It was only found at sites Ae and Af.

The snout of this species is much longer than that of the blacknose dace, *R. atratulus*, and its mouth is posterior to the tip rather than just behind the tip as in *R. atratulus*. It is also a larger, thinner, fish, reaching a maximum TBL of 16 cm (Page and Burr 1991), although most adults are 6-9 cm long, with 61-76 lateral line scales, and a decidedly longer caudal peduncle. The anal fin usually has eight (7-9) rays. Body pattern is similar to *R. atratulus*. Breeding males develop an reddish-orange upper lip, a reddish spot above the origin of the pectoral fin, and orangish-red fins.

Spawning occurs in 15-20 cm deep gravel riffles from April to June in northern Virginia and Maryland, after water temperatures rise above 16° C (Schwartz 1963, Ernst pers. obs.). Females produce over 100 eggs per season, with large females carrying as many as 680 (Carlander 1969). The nest site is prepared and guarded by the male (Cooper 1983).

Fry and juveniles are probably more planktonivorous than adults, feeding on algae and small microcrustaceans (Cooper 1983, Edwards et al. 1983b, Gerald 1966). Adults subsist primarily on both aquatic and terrestrial insects that drop or are washed into the water; beetles, various dipterans (both

larvae and adults), hemipterans, hymenopterans, mayflies, plecopterans, trichopterans, but also occasionally take mites, small snails and clams, tubellarian worms, and the fry of other fish species (Carlander 1969, Cooper 1983, Edwards et al. 1983b, Gerald 1966).

***Semotilus atromaculatus* (Creek Chub).** This large, robust minnow (maximum TBL, 30.5 cm; Lee et al. 1980) prefers small streams with sand, gravel or rocky bottoms, and it is one of the most common fish at Fort Belvoir (A6, A13, A15, A19, Aa, Ab, Af, Dc, G2, G5).

The creek chub is easily identified by its pointed snout, dorsal fin that begins behind the origin of the pelvic fin, large dark spot at the lower, front base of the dorsal fin, small black spot on the caudal peduncle at the tail fin, and small barbel in the corner of the jaws. Dorsal color is olive-brown, the venter is white to cream. Females are smaller than males, and, like the young, possess a dark lateral stripe that begins on the snout, continues through the eye, and extends to the tail. This stripe fades with age in males. Breeding males have orangish pectoral, pelvic and anal fins, orange pigment at the base of the dorsal fin, bluish-gray pigment on the top and sides of the head, and enlarged tubercles on the snout. Lateral line scales total 47-65.

Males from Fort Belvoir may possess nuptial tubercles and breeding pigmentation in November, but most breeding was noted between 20 May and 15 June. The male prepares a nest depression by carrying pieces of gravel from it in his mouth. Females may lay as many as 3,000 to 4,600 eggs in the depression, which the male then covers with gravel (Carlander 1969, Werner 1980).

Prey consumed are algae, plant debris, cladocerans, insects, small mollusks, and small fish (Carlander 1969, Cooper 1983, Jenkins and Burkhead 1994, Lee et al. 1980).

***Semotilus corporalis* (Fallfish).** This second species of chub at Fort Belvoir is very similar to *S. atromaculatus*, but adults differ in lacking dark pigmentation on the dorsal fin and usually at the base of the tail, and have no more than 50 scales in the lateral line. The fallfish is the largest native cyprinid in the Atlantic coastal drainages, reaching a record TBL of 51 cm (Page and Burr 1991).

Normally found near the mouths of slow flowing, gravel bottomed tributaries in waters cooler than 28° C, *S. corporalis* does not seem to ascend small tributaries at Fort Belvoir as often as does *S. atromaculatus*, and it was only recorded at sites Ab, Ae, Af, and G2.

In April and May males build elongated nests of piled gravel by carrying the individual pieces to the chosen site in their mouths (Jenkins and Burkhead 1994, Ross and Reid 1978, Schwartz 1963, Werner 1980). Males are territorial and guard the nests, which are only constructed by dominant individuals. A dominant male initiates spawning by swimming to the nest mound and dropping a pebble carried in its mouth, or by positioning himself slightly downstream and then rushing forward onto the nest (Ross and Reid 1978). Spawning may be communal, with as many as five individuals participating. Additional spawning behavior is described by Ross and Reid (1978). A female may produce 2,000 to 12,000 eggs a season (Jenkins and Burkhead 1994).

In a piedmont Virginia stream, insects comprised 73% and small fish 17% of the total prey eaten by *S. corporalis* (Flemer and Woolcott 1966). Insects taken include beetles, dipteran adults and pupae, dragonfly nymphs, hemipterans and hymenopterans (Carlander 1969, Flemer and Woolcott 1966).

CATOSTOMIDAE (Suckers)

***Catostomus commersoni* (White Sucker).** The white sucker may grow to 64 cm TBL (Page and Burr

1991). Its body color is silvery to light olive with some dark-edged dorsal scales. The snout is relatively blunt, the forehead flat, the mouth has papillous lips (the lower lip is twice as thick as the upper and not deeply indented), the opercular area is dark, the dorsal fin lacks dark pigment, 53-74 lateral scales are present, and the caudal fin is forked. The breeding male is yellowish with a reddish lateral stripe and small tubercles on the lower portions of the pelvic, anal and caudal fins.

This is the common sucker of the region, typically inhabiting clear, cool (upper lethal temperature is 27° C; Carlander 1969), riffles and pools in small to moderate streams with gravel bottoms. It is moderately tolerant of both siltation and pollution. Fort Belvoir records are from sites A15, A19, Aa, Ab, Af, and Pc.

A late March to May breeder, *C. commersoni* migrates at night up small tributary streams and brooks to gravel riffles. There, one or more males may court a single female (Ernst pers. obs.). Usually no nest cavity is prepared, and the fertilized eggs settle to the bottom and are eventually buried by gravel. A female may contain 10,000 to 140,000 eggs (Carlander 1969).

The species feeds on the bottom, and food preferences vary with age. Juveniles eat algae, microcrustaceans (particularly cladocerans), rotifers, and midge larvae; whereas adults consume chironomids, small crustaceans (cladocerans, copepods, ostracods), small clams, snails, oligochaete worms, fish eggs, and detritus (Carlander 1969, Flemer and Woolcott 1966, Hildebrand and Schroeder 1972, Ernst pers. obs.).

***Erimizon oblongus* (Creek Chubsucker).** This medium sized olive-brown fish (to 36 cm; Page and Burr 1991) has a relatively thick body, a slightly notched caudal fin at the end of a narrow peduncle, a rounded edge and 11-13 rays on the dorsal fin, dark-bordered scales, 5-8 dark blotches on each side of the body, no lateral line (but usually 40-45 lateral scales), and often yellowish fins. The small sucker mouth is slightly oblique and has thick, plicate lips. Breeding males develop orange pectoral and pelvic fins, yellow dorsal and anal fins, a bilobed anal fin, three tubercles on each side of the snout, and a pinkish-yellow venter. Immature individuals resemble other cyprinids in having dark dorsal and lateral stripes.

Found predominantly in patches of aquatic plants in the sand or gravel pools of slow moving streams, it was taken at A6, A15, Af, G2, G5, and Mulligans Pond. The subspecies at Fort Belvoir is *Erimizon oblongus oblongus*.

The breeding season usually covers the last half of March and April (Carlander 1969), but *E. oblongus* in breeding condition were captured in late May and June. Some sound production may be involved in courtship (Lee et al. 1980). Males construct nests in shallow upstream riffles by moving gravel with their mouths (Cooper 1983). Carlander (1969) reported that individual females may contain 8,694 to 72,360 eggs. After spawning, adults migrate downstream to deeper waters (Troutman 1957).

A bottom feeding omnivore, *E. oblongus* eats algae, plant debris, zooplankton, rotifers, and chironomid insects (Carlander 1969, Cooper 1983, Flemer and Woolcott 1966). About 61% of the creek chubsuckers examined by Flemer and Woolcott (1966) had eaten plants.

***Hypentelium nigricans* (Northern Hog Sucker).** This is the only sucker in northern Virginia bearing dark saddle-like bars (3-6) on its upper sides. It may grow to 61 cm TBL (Page and Burr 1991). Other distinguishing features include a concave forehead, blunt snout, sucker-like mouth with papillous lips, large pectoral fins, dorsal fin with two dark bars, forked caudal fin, and 44-54 lateral line scales. Breeding males have orange fins, and both breeding sexes develop tubercles over most of the fins and body (although those on females are smaller).

The hog sucker is typically a resident of riffles and pools in clear, moderate to large streams with bottoms ranging from sand to rocky, but usually gravel. Fort Belvoir records are from A6, A16, A19, Ae, Af, and G5.

Spawning in shallow riffles takes place in April and May at water temperatures usually above 16° C (Cross 1967), but males in apparent breeding condition were collected in July. During spawning the male lies beside the female, and often several males court the same female. The fertilized eggs drop between the gravel, where they develop with no parental care. The fecundity of *H. nigricans* has not been reported.

Hypentelium preys on bottom dwelling insect larvae, small crustaceans, oligochaete worms, small mollusks, algae, and organic debris (Carlander 1969, Cooper 1983, Werner 1980, Ernst pers. obs.).

POECILIDAE (Livebearers)

***Gambusia holbrooki* (Eastern Mosquitofish).** This small fish (usually less than 5 cm, but to 6.5 cm TBL; Page and Burr 1991) has been released for mosquito control and has subsequently become established in northern Virginia. However, it is possible that some populations in the region are native. It closely resembles the guppy of the pet trade (especially the females). Its body is olivaceous to tan, and each scale has a dark edge. The head is pointed and dorsally flattened. The dorsal fin begins behind the origin of the anal fin. The rounded caudal fin is unnotched, lies at the end of a relatively long peduncle, and has a narrow dark bar. A dark teardrop-shaped mark lies below the eye. The lateral scale series contains 26-32 scales. Males are smaller than females, and have the anal fin elongated into a gonopodium for transferring sperm during copulation. Breeding females develop a dark spot at the base of the anal fin. The subspecies at Fort Belvoir is *Gambusia holbrooki holbrooki.*

Mosquitofish prefer slow moving or standing bodies of water with much vegetation and a soft bottom; typically places where mosquitoes and other dipterans breed. They are relatively tolerant of both low oxygen and salinity. At Fort Belvoir *G. holbrooki* has been found at sites A15, Af, G2 and Mulligans Pond.

Breeding takes place throughout the warmer months (May-September, Carlander 1969). Gravid females were collected at sites Af and G2 in June and July. Being the only fish with internal fertilization in northern Virginia, a mating act is required during which sperm (milt) from the male runs down the trough-like gonopodium and into the female's urogenital pore. A female may produce over 200 eggs during the summer, usually in 3-4 broods (Cooper, 1983). After the copulatory act, she holds the eggs within her body as they develop (ovoviviparity). After 21-28 days the young emerge. Those produced in May probably mature by September.

Gambusia holbrooki usually feeds at the surface and mosquito larvae and pupae are preferred, but it will also consume copepods and other small zooplankton, other dipteran larvae and pupae, hemipterans, worms, small snails, larval fish, algae, and plant debris (Carlander 1969, Flemer and Woolcott 1966, Jenkins and Burkhead 1994, Lee et al. 1980, Ernst pers. obs.).

CYPRINODONTIDAE (Topminnows & Killifish)

***Fundulus diaphanus* (Banded Killifish).** Killifish have flattened heads with slightly upturned, terminal mouths, the dorsal fin set well posterior (originating between the pelvic and anal fins), the dorsal and ventral anterior extensions of the caudal fin projecting along the rather narrow caudal peduncle, and a squared (not forked) caudal fin. The two killifish of the region, *F. diaphanus* and *F. heteroclitus*, hybridize (Lee et al. 1980), making identification difficult.

Fundulus diaphanus (TBL to 13 cm; Page and Burr 1991) is distinguished from other *Fundulus* by its 18-20 (15-22) olive bars and thin caudal peduncle whose depth can be divided into the TBL more than nine times. It is dark olive-brown dorsally, white to cream ventrally, and may have some light yellow pigment on the fins. The anal fin has 9-13 rays, and faded narrow bands may be present on the dorsal and anal fins. No lateral line is present, but 35-52 scales lie in a longitudinal series where one would occur. Breeding males have more (15-22) and wider bars than females (8-15), a yellow throat, and brighter yellow fins. The subspecies present at Fort Belvoir is *Fundulus diaphanus diaphanus*.

The banded killifish is most often found in schools occupying the quiet waters of ponds, lakes, or slow-flowing streams with soft bottoms of mud or sand and beds of aquatic vegetation. In addition to the sites recorded (A13, A15, A16, A19, Aa, Ab, Ae, Db, G5, Pb, Pc), it is common in Gunston Cove. This fish is tolerant of high temperatures, and has been found in waters as warm as 38.3° C (Carlander 1969).

Spawning probably begins in April and continues into June in northern Virginia at water temperatures above 20° C (Carlander 1969); gravid females and males in breeding condition were taken at site G5a on 15 June. Clusters of up to 250 eggs are attached to aquatic plants by filaments (Richardson 1939). The eggs receive no parental care.

Fundulus diaphanus feeds on flying insects, planktonic crustaceans (including ostracods), mollusks, annelid worms, plant seeds, and algae (Carlander 1969, Hildebrand and Schroeder 1972). Unlike other killifish, it feeds at all strata of the water column (Cooper 1983).

***Fundulus heteroclitus* (Mummichog or Common Killifish).** Page and Burr (1991) do not consider this brackish water fish to occur in the freshwaters of northern Virginia, but it is mapped from freshwater by Jenkins and Burkhead (1994) and Robins et al. (1986). It is also listed as entering the freshwater streams of the Mid-Atlantic states by Lee (1976) and Lee et al. (1976), and Drs. R. Christian Jones and Donald P. Kelso (pers. comm.) have found it to be common in Gunston Cove. Specimens matching its description were found, along with *F. diaphanus*, at site G5a. The normal habitat of *F. heteroclitus* is the shallow, slow flowing waters of salt flats, brackish estuaries, or tidal creeks with abundant submerged vegetation. It is tolerant of low oxygen conditions.

The mummichog can be distinguished from *F. diaphanus* by the following suite of characters: usually 13-15 (10-18) dark olive lateral bars, 33-38 lateral line scales, 10-12 anal fin rays, TBL less than nine times the depth of the strongly compressed caudal peduncle, and relatively short, broad snout. The maximum TBL is 12.5 cm (Robins et al. 1986). Breeding males are dark-bodied with dark anal and dorsal fins (the last 4-5 rays of the dorsal fins may bear a dark blotch), females are always lighter with light fins. The subspecies found in northern Virginia is *Fundulus heteroclitis macrolepidotus*.

The mummichog spawns in shallow, slow-moving waters from April to September (Brummett 1966, Hildebrand and Schroeder 1972). Breeding males and gravid females were found on 15 June at G5a, the only site where the species was recorded. No nest is constructed. Large females may produce over 400 spherical eggs per season (Hildebrand and Schroeder 1972).

This species is omnivorous, feeding on algae, seeds, the debris of higher plants, annelid worms, small mollusks, various small crustaceans and insects, and small fish (Cooper 1983, Hildebrand and Schroeder 1972).

ANTHERINIDAE (Silversides)

***Menidia beryllina* (Inland Silverside).** This slender, elongated fish may reach 15 cm in TBL (Page

and Burr 1991); females grow larger than males. As with other members of the silverside family, *M. beryllina* is characterized by a bright silvery mirror-like stripe that extends along the side of its pale yellow body from the operculum to the base of the tail (no other fish in northern Virginia has such a stripe). The venter is white to cream. The snout is long, the head is flattened dorsally, and the eyes are rather large. The two dorsal fins are widely separated. The first is short and lies in front of the long, concave anal fin, which has 15-19 rays. The second dorsal fin is about as long as the anal fin. The caudal fin is moderately forked. The lateral line extends along 36-44 scales.

Menidia was only collected at site Pb. A common shore fish of the Chesapeake Bay (Hildebrand and Schroeder 1972), it often ascends freshwater tributaries at least as far as the tidal limits. Normally it is found in clear, slow moving waters with little wave action, and sand or gravel bottoms.

The reproductive strategies of *M. beryllina* are interesting. It has an extended spawning period lasting from April to September, but more gravid females are found in the spring than in the fall (Lippson and Moran 1974). It apparently experiences temperature dependent sex determination, as mostly females are produced from eggs laid in the cooler spring waters while almost 100% males are produced from eggs laid in the warmer waters of fall. This probably accounts for why females are much larger than males, since they have had several additional months to feed and grow before males hatch. The eggs are laid over the gravel bottom or a weed bed, where they adhere to the debris or plants.

Since their mouths are small, only small prey is consumed: algae, worms, insect larvae, amphipods, copepods, isopods, and mysids (Cooper 1983, Lee et al. 1980).

CENTRARCHIDAE (Sunfishes & Black Basses)

***Enneacanthus gloriosus* (Bluespotted Sunfish).** Several individuals were taken at site Db. Normally this species lives in weedy patches, often in bogs or marshes, in sluggish, often muddy, rather anoxic waters, and is a good indicator species for such aquatic conditions. It is also known from brackish waters near the mouths of streams flowing directly into the Chesapeake Bay (Hildebrand and Schroeder 1972), and is quite tolerant of salty conditions.

The bluespotted sunfish is a beautiful little species, reaching a record TBL of only 95 mm (Page and Burr 1991). Its short, deep body is olive above and yellowish below. Some faint bars may be present on the sides of adults. In the male the sides are speckled with light blue or silver spots. These light spots may also be present on the anal, long dorsal, and rounded tail fins, and orangish-red pigment may occur on the caudal and anal fins of breeding males. Females are less ornate and rather greenish in color. The operculum ends in two blunt points, and the dark opercular spot contains a smaller grayish-white spot. The lateral line contains 28-35 scales. Three short spines are present on the anal fin, and the pelvic fins when compressed against the body usually extend beyond the anterior origin of the anal fin. The pectoral fins are also relatively long.

Spawning in the region of the Chesapeake Bay apparently occurs in May and June (Hildebrand and Schroeder 1972), and at Fort Belvoir males are in breeding color during this period. The male defends a small territory around a solitary nest, but some eggs may be deposited over algal mats (Breder and Redmond 1929).

Since *E. gloriosus* is a short fish and has a correspondingly small mouth, it is limited to eating small prey. Food reported for this species includes amphipods, cladocerans, copepods, isopods, ostracods, dipteran larvae, nymphs of hemipterans and dragonflies, nematodes, snails, small clams, and some plant debris (Cooper 1983, Flemer and Woolcott 1966, Hildebrand and Schroeder 1972). Flemer

and Woolcott (1966) found that crustaceans comprised 55% and dipteran larvae 21% of the prey items recorded from bluespotted sunfish from the lower piedmont of Virginia.

***Lepomis auritus* (Redbreast Sunfish).** This fish is a main channel resident of Accotink and Dogue creeks (Ab, Af, Db). It inhabits quiet, sandy or gravely pools in small to medium streams. Areas with rocks, submerged logs, drowned tree trunks and weed beds are especially favored sites (Aho et al. 1986). Mostly solitary in the summer, *L. auritus* aggregates in winter at deeper water sites.

The redbreast is easily separated from the other sunfish at Fort Belvoir by the combination of an orange-red chest and belly (especially in breeding males); long, narrow, dark blue opercular flap; yellow flecks and red and orange spots on the upper olive sides; and yellowish-orange fins. When laid flat its rounded pectoral fins do not extend posteriorly to the anal fin. The lateral line contains 39-54 scales, there are 9-11 rays and three spines on the anal fin, and the pectoral fin has 13-15 rays. TBL may reach 24 cm (Page and Burr 1991), but most adults at Fort Belvoir are 10-15 cm long.

Spawning is in late May to at least July in northern Virginia (Ernst pers. obs.) at water temperatures of 20-29° C (Davis 1972a). The male usually clears a nest depression in the shelter of some large object, such as a boulder or log, in shallow sand or gravel-bottomed waters. Nests are 30-40 cm in diameter and about 15 cm deep, and several individuals may nest close to each other if suitable sites are scarce (Ernst pers. obs.). A female may contain 1,000 to 8,500 eggs (Carlander 1977, Werner 1980), and probably spawns only once a season (Aho et al. 1986).

Lepomis auritus feeds in the water column from the bottom to the top. Juveniles are probably more planktonivorous than adults, subsisting mostly on algae, arachnids, cladocerans and copepods. Adults are primarily insectivorous; 88% of the stomachs examined by Flemer and Woolcott (1966) contained insect remains. Insects eaten include both aquatic species and those that drop in or are washed in from the surrounding land. All stages of the insects life cycle are devoured. Adults consume beetles (especially curculionids), dipterans, dobsonflies, dragonflies, hemipterans, lepidopterans, mayflies, orthopterans, stoneflies, and trichopterans. Non-insect prey of adults includes oligochaete worms, earthworms, small snails and clams, and even small fish (Aho et al. 1986, Cooper 1983, Davis 1972a, Flemer and Woolcott 1966, Ernst pers. obs.).

***Lepomis cyanellus* (Green Sunfish).** A native of the Great Lakes and Mississippi watersheds, the green sunfish has been introduced into northern Virginia as a panfish or as prey for introduced blackbass. It is most often found in quiet, warm (26-30° C), sometimes muddy waters with abundant aquatic vegetation and soft bottoms, and does not tolerate brackish water (Carlander 1977). All Fort Belvoir records are from Accotink Creek (A6, A15, A16, Af).

Lepomis cyanellus is a medium-sized sunfish (maximum TBL 31 cm [Page and Burr, 1991] but usually under 25 cm) with a large, thick-lipped mouth that extends to the orbit. Its body is less rounded and more streamlined than that of the other sunfish at Fort Belvoir. Body color varies from green to blue-green with metallic green flecks and 7-11 dusky bars along the sides. A white-bordered blue spot is present at the posterior tip of the operculum, wavy stripes cross the cheeks, a dark blotch occurs at the base of both the anal and second dorsal fins, the second dorsal fin, anal fin and slightly notched caudal fin have yellow borders, and the venter is yellow to orange. The pectoral fin is short and rounded with 13-14 rays and the anal fin has 9-10 rays and three spines. Forty-one to 59 scales occur along the lateral line.

Long photoperiods (15-16 hours) and water temperatures above 20° C cause gonadal development in both sexes (Kaya and Hasler 1972), but temperatures above 24° C begin gonadal regression (Kaya, 1973). Spawning occurs from June to August (Hunter 1963). In mid- to late May

males fan their fins to clean circular areas about 31 cm in diameter in shallow gravel or sand near rocks, logs or vegetation. These nest cavities are defended throughout the spawning season, and one male may construct several adjacent depressions. Nesting may be colonial. Males court females that enter these depressions, and, after the 15 to 50 thousand fertilized eggs are deposited (Carson 1968), attend the nest until the fry hatch and leave (Hunter 1963).

Juveniles eat small crustaceans, such as cladocerans and copepods, and fish eggs. The diet of adults consists of aquatic and terrestrial insects, terrestrial arthropods, crayfish, small fish, and small mammals (Carlander 1977, Cooper 1983, Cross 1967, Jenkins and Burkhead 1994, Stuber et al. 1982).

***Lepomis gibbosus* (Pumpkinseed).** The pumpkinseed (to 40 cm TBL, but usually about 25 cm; Page and Burr 1991) is the most colorful sunfish of northern Virginia. Its greenish back and sides are speckled with numerous yellow, orange or gold flecks; a prominent red or orange white-bordered spot occurs at the posterior tip of the operculum; narrow bluish-green radiating stripes extend from the orbit and cheek onto the operculum; the dorsal, caudal and anal fins bear dark wavy bars or orange spots; and the venter is cream to orange. In addition, juveniles and mature females have 7-10 dusky bars on their sides. Other diagnostic features are a laterally compressed body, relatively small mouth that does not extend to the orbit, an elongated pectoral fin with 12-13 rays, a shallowly notched caudal fin, 10 anal fin rays, and 35-47 lateral line scales. Breeding males are more brightly colored than females, and have yellow pectoral fins.

Usually a resident of quiet streams, rivers or lakes with abundant aquatic weed beds, *L. gibbosus* is native to the region, but has also been artificially stocked as a panfish or as prey for introduced black bass (*Micropterus*) into ponds, impoundments and streams in northern Virginia. It is relatively tolerant of both low pH and oxygen levels, but lethal temperatures vary from 28° C to 36° C. At Fort Belvoir, *L. gibbosus* is the second most widely distributed sunfish (A15, Aa, Ae, Af, Db, Dc, Dd, G2, Pc, INSCOM Pond, Mulligans Pond), being surpassed only by the bluegill, *L. macrochirus*.

The potential breeding season is long, occurring anytime between May and August after water temperatures climb above 15° C. Usually the pumpkinseed begins to breed about three weeks before the bluegill spawns (Carlander 1977). Since it has such an extended spawning period, *L. gibbosus* sometimes hybridizes with other sunfish of its genus (Carlander 1977), such as both *L. macrochirus* and *L. cyanellus*. Like other centrarchids, male pumpkinseeds use their fins to clear a circular nest depression with a diameter about 3.5 times that of body length. The site is usually near the shoreline in quiet water less than 70 cm deep with a thin silt, gravel or rocky substrate. The male lures a female into the depression, courts her, and spreads his milt over the eggs she releases. Over 14,000 eggs may be deposited in a nest, and a female may carry over 29,000 eggs (Carlander 1977). Males are territorial, defending the nest cavity, developing eggs, and recently hatched fry. Nest sites are somewhat near each other, usually in groups of 2-3, but never in large colonies. After the spawning season, adult pumpkinseeds migrate back to deeper waters.

Pumpkinseeds are primarily carnivorous, with plant materials probably only ingested secondarily. Most feeding is during daylight hours, and at all levels of the water column. Snails comprise a high percentage of prey items, but oligochaete worms, crustaceans (amphipods, copepods, isopods, ostracods), insects (chironomids, larval and pupal dipterans, dobsonfly larvae, hemipterans, mayfly nymphs, plecopterans, trichopterans), and even small fish are eaten (Carlander 1977, Flemer and Woolcott 1966, Hildebrand and Schroeder 1972, Ernst pers. obs.). Flemer and Woolcott (1966) found dipteran larvae in 57% of the stomachs they examined from a Virginia stream. The total digestive process takes 15-20 hours (Kitchell and Windell 1968).

***Lepomis gulosus* (Warmouth).** Adults of the warmouth grow to a maximum TBL of 31 cm (Page and Burr 1991), and it is considered a desirable sport fish. Its deep body is brown above and cream below. The sides and venter contain lighter olive-brown, green, bluish, golden or whitish iridescent spots and blotches which are often arranged in 6-9 poorly defined bars. Three to five reddish-brown stripes occur on the cheek, and the operculum is adorned with a black, light-bordered, terminal spot. The iris of the eye is red. The dorsal, caudal and anal fins are mottled with light spots; the pale pectoral fins bear dark streaks. Breeding males have an orangish-red spot on the back at the base of the second dorsal fin which is absent or only poorly developed in females. Reproductive adults of both sexes are more brightly colored than nonbreeding individuals. The mouth is large with thick lips. The lateral line covers 36-48 scales, and the anal fin has three spines.

The warmouth usually lives in deep pools, swamps, and backwaters. At Fort Belvoir one was netted at Mulligans Pond and another at site Dc. Since the pond is connected to Dogue Creek, the origin of the individual taken there is unknown. It is possible that it was introduced, since the fish has previously been stocked in the Potomac River (Jenkins and Burkhead 1994).

The breeding period covers the spring and early fall, but it is possible that this fish also breeds in the fall (Carlander 1977). Males clear and defend rounded nest depressions in covered areas, such as weedbeds with rubble and loose sticks, in water at least one meter deep. Females spawn several times a season, producing 4,500-63,200 eggs (Larimore 1957). Warmouths hybridize with both green sunfish and bluegills (*Lepomis macrochirus*).

Prey consists of small crustaceans (cladocerans, copepods), insect larvae and nymphs, adult insects, snails, crayfish, and smaller fish (Carlander 1977, Flemer and Woolcott 1966, Jenkins and Burkhead 1994, Larimore 1957). Flemer and Woolcott (1966) reported that insects are the most important food, comprising 58% of all food items, followed by crayfish (17%). The insects eaten included dipteran larvae, dragonfly and mayfly nymphs, adult hemipterans and orthopterans.

***Lepomis macrochirus* (Bluegill).** This is the ubiquitous sunfish of the region, and the most common and widespread at Fort Belvoir, having been recorded at all collection sites. Unfortunately, the taxonomy of the local population is confused. Originally, only the native eastern subspecies *Lepomis macrochirus purpurescens* was present; however, since the species is a popular panfish and favorite prey of introduced blackbasses, bluegills from other parts of the country have been frequently released in northern Virginia (it was stocked in the INSCOM and Mulligans ponds, Morton et al. 1991) resulting in interbreeding with the native stock. The species is now present in all watersheds and in many impoundments and local ponds in northern Virginia. If the waterbody is relatively shallow and has a soft bottom and abundant aquatic vegetation, *L. macrochirus* may occur in large numbers.

The bluegill has a laterally flattened, somewhat disc-shaped, body that may grow to a TBL of 41 cm (Page and Burr 1991), but most individuals are 20-30 cm long. If the population in a waterbody is large, the bluegills tend to be stunted. The back is olive with yellowish-green flecks; the venter is cream to yellow. Nine to 12 bars may be present along the upper sides, particularly in juveniles. The blue-black opercular spot is elongated and lacks a light border, and there is a dark spot at the base of the second dorsal fin. Two bluish stripes cross each cheek. The pectoral and pelvic fins are elongated, and latter fin extends beyond the origin of the anal fin when laid flat against the abdomen. The mouth is small and does not extend to the orbit. The pointed pectoral fin has 13 rays, the anal fin 9-11 rays, and 38-48 scales lie along the lateral line. Breeding males develop bluish heads, black pelvic fins, and bright orange venters. Females always have a small, swollen, doughnut-shaped ring around the urigenital pore that is absent in males (McComish 1968).

Northern Virginia bluegills have a long spawning season which may last from late May in warm years to August or September, peaking in June (Ernst pers. obs.). A gravid female was even collected on 2 November at Fort Belvoir. Females may spawn up to five times a season, producing about 80,000 eggs (Carlander 1977). The male uses his fins to fan the sand, mud, or gravel bottom in shallow water (usually less than 1.2 m deep) to produce a clear circular depression about 30 cm in diameter. The site chosen is usually in full sunlight, or receives sunlight for a portion of the day. Males are territorial, but territories are normally small so nest depressions are not far separated. Courting males may vocalize (Gerald 1971).

Lepomis macrochirus eats a variety of foods: algae, aquatic plants, amphipods, cladocerans, copepods, ostracods, fish lice (*Argulus*), rotifers, water mites, isopods, spiders, insects (coleopterans, dipteran larvae and pupae, mayfly nymphs, hemipterans, hymenopterans, lepidopteran larvae, dobsonfly larvae, dragonfly nymphs, orthopterans, plecopteran adults and nymphs, psycopterans, trichopteran larvae), horsehair worms, oligochaete worms, snails, and small fish (Carlander 1977, Flemer and Woolcott 1966). In a study of bluegills in a Virginia stream, insects comprised 65% and crustaceans 29% of the diet (Flemer and Woolcott 1966).

***Lepomis megalotis* (Longear Sunfish).** The longear sunfish (maximum TBL to 24 cm, Page and Burr 1991) is one of the more easily identified centrarchids. Its elongated, rectangular, bluish-black, orange or reddish-orange bordered, posterior opercular extension and rounded pectoral fins separate it from all other local sunfish. Other local sunfish have pointed pectoral fins. The back and sides are red to orangish-brown and the venter, cheek and operculum are orange. Blue spots adorn the back and sides, whereas the venter is patterned with blue flecks, and wavy blue stripes cross the cheeks and opercula. The iris is red and black. The dorsal, caudal and anal fins are olive-gray with blue spines and rays. The pelvic fins are black, and the pectoral fins are pale. Breeding males have black anal fins. The dorsal fin has 10-12 rays and 9-11 spines, the anal fin 9-10 rays and three spines. The lateral line involves 36-46 scales.

The longear sunfish normally lives in shallow, warm, sluggish pools and backwaters in sandy or rocky streams and rivers. Jenkins and Burkhead (1994) report it only from above the Great Falls of the Potomac River, stating that it has been introduced in the Potomac watershed. It was taken only at Mulligans Pond and at site Dc.

Lepomis megalotis spawns in the late spring and early summer at water temperatures of at least 25° C (Jenkins and Burkhead 1994). The male constructs and defends a nest cavity in sand or gravel in shallow water. Nesting is usually colonial (Carlander 1977). Males vocalize during courtship (Gerald 1971). Females may produce 700 to 900 eggs per season, and spawn several times with different mates (Carlander 1977, Jenkins and Burkhead 1994). This fish hybridizes readily with green sunfish, pumpkinseeds, and bluegills.

Natural foods include microcrustaceans, snails, leeches, aquatic insects (all life stages), and the eggs and fry of other fish (Cooper 1983, Jenkins and Burkhead 1994, Pfleger 1975).

***Micropterus dolomieu* (Smallmouth Bass).** A popular gamefish, *M. dolomieu* has been widely stocked in northern Virginia; it is not native to the Atlantic coastal drainages. Clear, fast-flowing, cool (20-25° C), gravel-bottomed streams with alternating pools and riffles are the best habitat for this fish. At Fort Belvoir it has been stocked in Mulligans Pond (Morton et al., 1991), and collected in all three of the installation's primary streams (A15, Ab, Af, Dc, Pc).

The smallmouth is so named because its mouth (i.e., upper jaws when mouth is closed), while large, only extends backward to the level of about the middle of the eye, as compared to largemouth

basses in which the very large mouth extends backward to the rear margin of the eye or beyond. The body is streamlined, olive-brown with dark mottling dorsally, white to cream below, and has a series of dark bars along the sides and several dark radiating stripes on the cheek. No lateral stripe is present, as in largemouth basses. The eye is red, and the fins lack pigment, except in juveniles which have yellow and black pigment on the caudal fin. The anal fin has 9-12 rays, and 68-80 scales lie along the lateral line. Maximum TBL is 69 cm (Page and Burr 1991).

Spawning usually begins early in April after water temperatures reach 13-21° C (Carlander 1977), and normally lasts into May or early June. At Fort Belvoir most spawning takes place in small tributary streams during the first two weeks of May. A female may produce 2,000 to 15,000 eggs per season (Carlander 1977). The territorial male fans out a nest depression about 60 cm in diameter with his caudal fin, and may move large pebbles with his mouth. Nests are constructed in coarse gravel in water about a meter deep, and one may be used by several females.

Young smallmouth bass feed on small invertebrates such as cladocerans, copepods, rotifers, chironomids, mayfly nymphs, and dipteran larvae. Adults take larger prey: insects, crayfish, frogs tadpoles, and small fish (Carlander 1977, Edwards et al. 1983a).

***Micropterus salmoides* (Largemouth Bass).** The largemouth bass is native to the Great Lakes and Mississippi River drainages, but has become the most important introduced gamefish in many other parts of North America, including northern Virginia. At Fort Belvoir it has been stocked in Mulligans and the Gulf Coarse ponds (Morton et al. 1991), and was taken at sites Dd and Pb. Typical habitat is clear, quiet, soft-bottomed, and well vegetated. Water temperatures of 26-32° C are best, and a temperature of 36° C may be lethal (Carlander 1977).

A larger species than the smallmouth bass, *L. salmoides* has reached a record 97 cm TBL (Page and Burr 1991), although most adults are under 50 cm. Its elongated body is dark olive above and white to silver below. A black lateral stripe is always present, and usually three dark stripes cross the cheek. Little or no pigment occurs on the fins. The eye is brown. The mouth is large and extends to, or beyond, the posterior margin of the orbit. The anterior spiny-rayed portion of the dorsal fin is almost separated from the posterior soft-rayed portion. The first dorsal fin is highest in the center. The anal fin has 10-12 rays (three spines). Lateral line scales total 60-72. The scaleless area around the urigenital opening is nearly circular in males but elliptical in females (Parker 1971).

The spawning season is April through June, and water temperatures of 16-20° C initiate breeding. Males clear areas in the soft-bottom, often near rocks or logs, but never in silt. This area is larger than the typical nest depression of sunfish (*Lepomis*). Water depth is normally less than a meter. A large female may produce over 100,000 eggs per season, but most females probably lay only 10,000 to 30,000 eggs annually (Carlander 1977). Males guard the eggs until they hatch, and then the fry about a month more (Werner 1980).

Largemouth bass begin to feed when the water warms to 16° C, and continue to forage until water temperatures reach 35° C. Juveniles consume cladocerans, amphipods, rotifers, small crayfish, dragonfly nymphs, midge larvae, chironomids, orthopterans, hymenopterans, beetles, and oligochaete worms. Adults take a variety of larger animals: crayfish, various small fish, salamanders, tadpoles and adult frogs, small turtles and snakes, birds, and small mammals (Carlander 1977, Cooper 1983, Flemer and Woolcott 1966, Ernst pers. obs.). Large *M. salmoides* are even cannibalistic on smaller individuals of their own species (Carlander 1977).

***Pomoxis nigromaculatus* (Black Crappie).** This fish was only collected at Mulligans Pond and site Pc. The black crappie is a popular sport and panfish that has been occasionally stocked in northern

Virginia; however, the region is within the natural range of the species. Typical habitat is a quiet, clear, weedy pool with a sand, silt or mud bottom. Often many individuals congregate about submerged trees.

Pomoxis nigromaculatus (maximum TBL, 49 cm; Page and Burr 1991) is a rather humpbacked centrarchid with a relatively small head and an upturned snout. A sharp dorsal dip is present above the eye. The laterally compressed body is silvery-gray to greenish with a mottled pattern of black spots or wavy lines (juveniles) and olive-green flecks on the sides. The venter is white. The dorsal, anal, and caudal fins are patterned with dark spots arranged in wavy bands. The anal fin has 5-7 spines and 16-19 rays. The dorsal fin has 7-8 spines, which become increasingly longer from anterior to posterior, and 14-16 rays. Lateral line scales total 36-44. The black crappie's reproductive behavior is similar to the other centrarchids at Fort Belvoir. Spawning begins in April and may last to early July; apparently a water temperature above 15° C is needed (Jenkins and Burkhead 1994). The males prepare nest depressions in the sand or silt bottom in rather deep water (1-6 m), often among rooted plants and under overhead cover. Several males may place their spawning depressions close together, possibly because of a lack of suitable sites, but are still territorial. A female may contain 11,000 to 188,000 eggs (Jenkins and Burkhead 1994), but usually less than 60,000 eggs are laid (Werner 1980).

Juveniles are planktonivorous and consume great numbers of microcrustaceans (copepods); with increasing age they graduate to larval and adult insects (dipterans, mayflies, dragonflies, and terrestrial species that fall into the water). Adults eat worms, insects, small crayfish, and the fry, juveniles and adults of other fish, usually under 5 cm long (Cooper 1983, Flemer and Woolcott 1966, Jenkins and Burkhead 1994, Ernst pers. obs.). Adults are also cannibalistic on smaller individuals of their own species.

MORONIDAE (Temperate Basses)

***Morone americana* (White Perch).** Fish belonging to this family can be separated from those of the related sunfish and black basses by their fully, or almost fully, divided dorsal fin (the first dorsal fin has nine spines, the second has one spine and 11-14 rays), and the large backward pointing spine at the rear edge of the operculum. The only species at Fort Belvoir is *Morone americana*, which was found in the INSCOM Pond (obviously stocked) by Morton et al. (1991), and by us at sites Aa and Pc. It may grow to 58 cm TBL (Page and Burr 1991), but most adults are only 20-30 cm. The adult white perch has its silvery-olive to brownish-gray back and sides unpatterned, venter white, fins grayish, and 7-10 anal fin rays. The lateral line covers 44-52 scales. Juveniles may have some dark side bars. The cleft separating the spiny and soft dorsal fins is shallow in this species.

Morone americana is primarily common in soft-bottomed waters, such as the Potomac River and Chesapeake Bay (Hildebrand and Schroeder 1972). Schools of this fish are seasonally present in Gunston Cove off Fort Belvoir, and, judging from the many fall juveniles found there, the cove is a major spawning ground. Some adults also make spawning runs up the major creeks flowing through the military reservation. We have not witnessed any reproductive behavior at the installation, but the species spawns in April, May and December in the Chesapeake Bay (Hildebrand and Schroeder 1972). Cooper (1983) reported that one female may be courted by several males in open water, with much milling about and splashing at the surface. No nest depression is prepared, nor are the young fry protected. A female may produce hundreds of thousands of adhesive eggs (Werner 1980).

Feeding schools of *M. americana* may cover a large area, and forage at several depths in the water column. Zooplankton (amphipods, cladocerans, copepods, ostracods, rotifers) is a favorite food of the young, but larger prey, such as insects (chironomids and other dipterans, beetles, collembolans, hemipterans, lepidoptera larvae, dragonfly nymphs, crickets, grasshoppers, trichopterans), grass shrimp, crayfish, and small fish are taken by the adults (Blumenshine 1992, Cooper 1983, Jenkins and Burkhead 1994, Werner 1980).

PERCIDAE (Darters, Perch & Walleyes)

***Etheostoma olmstedi* (Tessellated Darter).** This small percid (TBL to 11 cm, Page and Burr 1991) is common in the riffles and small sandy or gravely pools in most waterways at Fort Belvoir, and has a relatively high tolerance for saltwater. It has been collected at sites A6, A13, A15, A19, Aa, Ab, Af, Dc, and Mulligans Pond.

The tessellated darter is light tan to olivaceous with a series of 9-11 small dark X or W-shaped marks along the side of the body, and, in some, a small faint spot at the base of the tail. Its head is dark with a blunt snout. The pectoral fins are large, and the dorsal fin is subdivided into anterior and posterior halves (the posterior dorsal fin has at least 13 rays). The posterior margin of the tail is complete (not notched), and the anal fin has only one spine. During the nonbreeding season the fins contain faint dark bars. A "teardrop" dark mark is present below the eye. Lateral line scales total 34-64 (Kuehne and Barbour 1983). Bodies of breeding males become darker, black pigment develops on their pelvic and anal fins, and the posterior dorsal fin enlarges. Two subspecies, *Etheostoma olmstedi olmstedi* and *E. o. atromaculatum,* are present at Fort Belvoir. Yarrington (1994) reported that Fort Belvoir's population of tessellated darters is an intergrading swarm that possibly forms a "polypheletic subspecies."

The spawning season encompasses April and May. During this period breeding males defend territories around flat stones. The male scoops out a depression under the stone and cleans its underside (Kuehne and Barbour 1983). Spawning is accomplished upside down with the male and female usually head to head beside each other (Kuehne and Barbour 1983). During the act the female attaches several eggs to the underside of the rock. A female may lay 30 to 200 eggs during the spawning period, and males apparently mate with several females each season.

Etheostoma olmstedi feeds predominately on insect larvae (particularly chironomids and trichopterans), zooplankton (especially crustaceans), and algae (Cooper 1983, Kuehne and Barbour 1983, Werner 1980).

***Perca flavescens* (Yellow Perch).** Although native to the Atlantic drainage of the middle Atlantic states, *Perca flavescens*, in its popular roles as both a sport fish and panfish, has also been widely stocked in northern Virginia. It normally lives in clear, cool, sandy-bottomed waters with abundant plant beds. A schooling fish, the yellow perch achieves its greatest numbers in lakes, ponds, and large rivers, but it will enter small tributary streams to spawn. At Fort Belvoir it has only been collected at Mulligans Pond (Morton et al. 1991) and at site Aa; however, it is not uncommon in Gunston Cove (Donald Morgan, pers. obs.).

Perca flavescens has a yellow to yellowish-olive, compressed body with a pattern of 6-9 dark bars on its back and sides, a white venter, and grayish-olive fins. The first (spiny) dorsal fin has a dark blotch at its posterior base. The caudal fin is barely notched, and the pelvic fins are closely situated (almost touching at the base), the anal fin has two spines and 6-8 rays, and 50-70 scales lie along the lateral line. The TBL may be as great as 40 cm (Page and Burr 1991), but most adults are 17-25 cm.

The yellow perch spawns in late winter and early spring in a rather narrow range of water temperatures, beginning at 10° C and usually stopping when the water temperature climbs above 12° C (Werner 1980). Spawning is often nocturnal, and the fish may migrate up small tributaries to shallow water. Several males usually court one female, and these all contribute milt (sperm) to fertilize the long gelatinous string of eggs she finally releases. Such egg tubes may be over 200 cm long, and may be folded back upon themselves in a pleated manner (Werner 1980). Often the egg tubes are draped around vegetation or submerged objects. Each female may produce over 100,000 eggs, but the average is about one fourth this number (Werner 1980). No territorial behavior occurs.

The species usually feeds during the day. Food includes amphipods, cladocerans, copepods, isopods, snails, earthworms, oligochaete worms, crayfish, crabs, shrimp, various insect larvae and nymphs, and small fish (Cooper 1983, Cross 1967, Hildebrand and Schroeder 1972, Pfleger 1975, Werner 1980).

Possible future additions to the fish fauna of Fort Belvoir.

Several other species of fish have been reported from northern Virginia streams or from the Potomac River near Fort Belvoir by Jenkins and Burkhead (1994). It is probable that some of these may occasionally enter the waterways of the installation. Following is an annotated list of these species.

FAMILY ACIPENSERIDAE

Acipenser brevirostrum (Shortnose Sturgeon) and *A. oxyrhynchus* (Atlantic Sturgeon) have both been collected from the Potomac River near Fort Belvoir. The former species is represented by a single specimen (USNM 26273) taken in 1876. It is considered extirpated from this portion of the Potomac River (Burkhead and Jenkins 1991, Kelso 1992). Kelso (1992) also considered *A. oxyrhynchus* extirpated in the upper Potomac since the last specimen was collected in 1968; however, Burkhead and Jenkins (1991) considered it a Species of Special Concern since individuals of this species still migrate to the Chesapeake Bay and enter some of its major tributaries. It could appear in the Potomac off Fort Belvoir. *Acipenser brevirostrum* is listed as Endangered under the Federal Endangered Species Act.

FAMILY AMIIDAE

Amia calva (Bowfin) has been caught in the Potomac River both upstream and downstream of Fort Belvoir, but, apparently, never in Gunston Cove (Donald P. Kelso pers. comm.).

FAMILY CLUPIDAE

Alosa aestivalis (Blueback Herring), *A. pseudoharengus* (Alewife), *A. sapidissima* (American Shad), and *Dorosoma petenense* (Treadfin Shad) all occur in the Potomac River off northern Virginia. The alewife, blueback herring and American shad are anadromous species that make spring spawning runs into tributaries of the Chesapeake Bay, and probably some enter Fort Belvoir's streams at such times. The threadfin shad was introduced to the Atlantic slope of Virginia as a forage prey for game species. Kelso (1992) reported that *A. aestivalis*, *A. pseudoharengus*, and *A. sapidissima* have declined in abundance in the region in recent years.

FAMILY ESOCIDAE

The large game species *Esox lucius* (Northern Pike) and *E. masquinongy* (Muskellunge) have been stocked in northern Virginia's piedmont streams and impoundments. Although the northern pike has not been caught in recent years, some muskellunge still survive in Burke Lake Park, Fairfax County. The smaller species *E. americanus* (Redfin Pickerel) and *E. niger* (Chain Pickerel) are also known from northern Virginia waterways. The latter is considered uncommon at best, having declined in recent years (Kelso 1992), and the former also seems to be declining in the region. The best potential habitat for the redfin pickerel at Fort Belvoir is at the Jackson Miles Abbott Wetland Refuge; however, although particularly searched for, it was not found there.

FAMILY ICTALURIDAE

Two riverine species of catfish occur in the Potomac River off Fort Belvoir and may occasionally enter

Gunston Cove and the installation's streams; *Ameiurus catus* (white catfish) and *Ictalurus furcatus* (Blue Catfish). The small catfish *Noturus gyrinus* (Tadpole Madtom) and *N. insignis* (Margined Madtom) occur in streams in Fairfax County, Both have been collected from Gunston Cove after spring floods (Ernst and Morgan pers. obs.) and may have been washed through Fort Belvoir at those times.

FAMILY CYPRINIDAE

The Grass Carp, *Ctenopharyngodon idella*, has been stocked at Burke Lake Park, Fairfax County. *Notropis buccatus* (Silverjaw Minnow) has been recorded from Fairfax County streams above the fall line, and it may wash into Fort Belvoir during spring floods. *Notropis amoenus* (Comely Shiner) is known from several watersheds in northern Virginia, and may also be present in small numbers in the upper reaches of the main streams flowing within Fort Belvoir.

FAMILY CATOSTOMIDAE

Records exist for both *Carpiodes cyprinus* (Quillback) and *Moxostoma macrolepidotum* (Shorthead Redhorse) from the Potomac River near Fort Belvoir. Normally deeper water fish, both may enter the larger creeks at Fort Belvoir during their spring and early summer spawning periods.

FAMILY SALMONIDAE

A native population of the brook trout, *Salvelinus fontinalis*, formerly inhabited Difficult Run in Fairfax County (Lovich 1984), but the species has been extirpated by development and the introduction of *Salmo trutta* (Brown Trout). The latter species and *Oncorhynchus mykiss* (Rainbow Trout) are popular game fish that have been introduced into several piedmont streams in Fairfax County.

FAMILY CENTRARCHIDAE

Ambloplites rupestris (Rock Bass) was formerly stocked as a game fish in northern Virginia, but probably no populations presently exist (Kelso 1992). *Lepomis microlophus* (Redear Sunfish) has also been stocked in Fairfax County, and a few probably still live in the piedmont streams from which they could enter Fort Belvoir. *Pomoxis annularis* (White Crappie) has been stocked in northern Virginia.

FAMILY MORONIDAE

Morone saxatilis (Striped Bass) is common in the Potomac River, and it probably occasionally enters at least the mouths of the larger streams of the installation.

FAMILY PERCIDAE

Four additional darters have been recorded in northern Virginia and the Potomac River. *Percina caprodes* (Logperch) was last found in the Potomac River in 1938, and is considered extirpated in the region by Burkhead and Jenkins (1991). *Percina notogramma* (Stripeback Darter) and *P. peltata* (Shield Darter) occur in both the coastal plain and piedmont portions of some streams in Fairfax County, and may be present in the upper reaches of all three major streams flowing through Fort Belvoir. *Etheostoma flabellare* (Fantail Darter) is a common resident of piedmont streams in northern Virginia, and Ernst has collected it from Gunston Cove after spring floods.

FAMILY SCIAENIDAE

Leiostomus xanthurus (Spot) is the only drum in the region. It is common in the shallows of the

Chesapeake Bay, especially near the mouths of tributaries, and probably inhabits the tidal portions of most of the larger tributaries. It appears in the outer Gunston Cove each August, but has not been taken in the inner cove or feeder creeks (Donald P. Kelso pers. comm.).

Acknowledgments

We thank Steven W. Sekscienski for providing collecting permits and logistical help. Jeffrey M. Clayton provided data on fish from northern Virginia streams in the collection of the USNM, confirmed the identification of the *Petromyzon marinus* from Accotink Creek, and helped us obtain critical literature. John Wilder and James C. Wilgenbusch prepared Figure 1. Drs. R. Christian Jones and Donald P. Kelso gave us advice throughout the project, and shared data on the fish community of Gunston Cove. Rumal B. Rackley took part in several collecting trips. The study was partially funded under Department of the Army, Ft. Belvoir, Virginia, contracts DAHC 35-92-P-6105 and DAHC 35-93-P-5921.

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Appendix 1: Physical characteristics of aquatic collection sites, 1993 - 1994

Location *
The first character (capital letter) refers to; **A**, Accotink Creek; **D**, Dogue Creek; **G**, Gunston Cove; and **P**, Pohick Creek. If the first character is followed by a number (e.g. A**6**a), the location refers to a primary creek entering the respective waterway. Number **1** refers to the creek located closest to the mouth of the respective waterway or to the western most creek entering Gunston Cove from Fort Belvoir. If the first character is followed by a lower case letter (e.g. A**a**) the collection site is the main channel of the corresponding creek. Lower case **a** is located at the mouth of each creek and higher letters are located relatively further upstream. The final character or digit (e.g. A13**a** or Ae**1**) refers to the relative position in the corresponding stream; where the lower character or digit is closest to the mouth of the corresponding waterway. Each section is approximately a 100 meters. (See Figure 1, page 2.)

Bottom
1 = gravel
2 = silt/mud
3 = artificial

Canopy
1 = open
2 = mostly closed
3 = closed

Location *	Order**	Width (m)***	Bottom	Canopy	NOTES
A13a-b	1	2.5	2	2	Silt from construction
A15a-b	1	6.1	1	3	
A15c-d	1	4.6	1	3	
A15e-f	1	4.6	1	3	
A15g	1	2.7	1	3	
A16a	1	4.3	1	2	
A19a-b	1	9.5	1	2	
A19c-d	1	11.3	1	3	
A6a-b	1	4.6	2	2	
A6c-d	1	4.6	1	2	
A6e-f	1	4.5	3	1	Section of gravel spillway
A6g-h	1	4	1	2	
A6i-j	1	4.6	1	3	
A6k-l	1	3.8	1	3	
A6m-n	1	3.2	1	3	
Aa	3	20	2	1	
Ab	3	25	2	1	
Ae8-9	3	25	1	1	
Af1-2	3	21.3	1	1	
Db	3	10	2	1	
Dc	2	5	2	1	Very channelized
Dd	2	-	2	1	Marsh/Abbot Refuge
G2a-b	1	4.2	2	1	Shallow beaver pond
G2c-d	1	3.2	1	2	
G3e-f	1	3.0	1	3	
G5a-b	1	3	2	1	
G5c-d	1	3	1	3	Remnants of oil spill
G5e-f	1	2.8	1	3	Ground water contamination
Pb	3	20	2	1	
Pc	3	10	1	1	Section below sewage effluent
Mulligan	-	50 x 210	2	1	Mulligan's Pond/Abbot Refuge

**Horton-Strahler method (Horton 1945, Strahler 1952).

*** Width of stream is a measure of bankfull width (straight-line measure from bank to bank perpendicular to stream flow).

Appendix 2: Fish Abundance and Sizes by Waterways, 1993-1994.
Analysis Variable : SIZE

------------------------------LOCATION=A6 ------------------------------

SPECIES	N Obs	Mean	Min	Max
Rhinichthys atratulus	1217	4.52	2	7.5
Lepomis macrochirus	4	7.45	5	3.5
Anguilla rostrata	43	22.3	10	53
Cyprinella spiloptera	171	6.82	2.5	73
Semotilus atromaculatus	223	7.87	2.5	19
Erimyzon oblongus	25	11.9	5.8	18.5
Lepomis cyanellus	1	10	10	10
Etheostoma olmstedi	10	6.14	5.5	7
Pimephales notatus	4	5.55	4.5	7.2
Clinostomus funduloides	107	6.04	3.5	17
Hypentelium nigricans	22	10.3	5.5	15.5
Umbra pygmaea	7	5.57	4.5	8
Notropis procne	1	11.5	11.5	11.5

------------------------------LOCATION=A13 -----------------------------

SPECIES	N Obs	Mean	Min	Max
Rhinichthys atratulus	7	5.36	3.5	6.5
Lepomis macrochirus	1	4.5	4.5	4.5
Anguilla rostrata	4	14.3	10	16
Cyprinella spiloptera	2	8.35	8.2	8.5
Semotilus atromaculatus	2	7.5	6.5	8.5
Fundulus diaphanus	1	5.5	5.5	5.5
Etheostoma olmstedi	4	5.63	4.5	7
Umbra pygmaea	3	6.67	5	7.5

---------------------------LOCATION=A15 -------------------------------

SPECIES	N Obs	Mean	Min	Max
Rhinichthys atratulus	801	4.19	1	7.5
Lepomis macrochirus	176	4.99	2.5	9
Anguilla rostrata	16	22.8	10	32
Cyprinella spiloptera	44	4.09	2.5	7
Gambusia holbrooki	10	2.95	2.5	3.5
Semotilus atromaculatus	88	8.34	3	18
Fundulus diaphanus	16	4.41	3.5	6
Erimyzon oblongus	7	7.79	3.5	15
Lepomis cyanellus	8	8.19	3.5	12.5
Hybognathus regius	56	4.82	2.5	9
Etheostoma olmstedi	3	5.33	5	5.5
Lampetra aepyptra	1	12.5	12.5	12.5
Clinostomus funduloides	33	6.61	5	9.5
Catostomus commersoni	1	9.5	9.5	9.5
Micropterus dolomieu	2	7.25	6	8.5
Luxilus cornutus	11	7.73	5.5	10.5
Lepomis gibbosus	1	13.5	13.5	13.5

Appendix 2: Fish Abundance and Sizes by Waterways, 1993-1994. (continued)

-----------------------------LOCATION=A16 -----------------------------

SPECIES	N Obs	Mean	Min	Max
Rhinichthys atratulus	37	4.42	2.5	5.5
Lepomis macrochirus	7	4.93	4	6
Anguilla rostrata	1	11	11	11
Cyprinella spiloptera	29	4.62	3	6.5
Fundulus diaphanus	65	4.84	3.5	7.5
Lepomis gibbosus	1	6.5	6.5	6.5
Hypentelium nigricans	1	5.5	5.5	5.5

-----------------------------LOCATION=A19 -----------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	33	3.84	2.5	6.8
Lepomis macrochirus	11	7.53	3.4	12
Anguilla rostrata	4	28.1	12.5	40
Cyprinella spiloptera	175	4.43	2.7	8.6
Semotilus atromaculatus	1	9.1	9.1	9.1
Fundulus diaphanus	296	6.21	3.4	9
Hybognathus regius	19	4.63	2.7	8.9
Etheostoma olmstedi	25	4.52	2	6.8
Catostomus commersoni	4	18.3	5.5	38
Luxilus cornutus	15	8.55	5.5	14.5
Hypentelium nigricans	1	8.5	8.5	8.5
Ameiurus nebulosus	2	11.7	7.4	16
Notropis hudsonius	860	4.42	2	8.6

-----------------------------LOCATION=Aa -----------------------------

Species	N Obs	Mean	Min	Max
Semotilus atromaculatus	1	-	-	-
Fundulus diaphanus	112	-	-	-
Hybognathus regius	19	-	-	-
Etheostoma olmstedi	12	-	-	-
Catostomus commersoni	18	-	-	-
Luxilus cornutus	29	-	-	-
Lepomis gibbosus	2	-	-	-
Notropis procne	63	-	-	-
Notemigonus crysoleucas	2	-	-	-
Notropis hudsonius	6	-	-	-
Morone americana	10	-	-	-
Perca flavescens	2	-	-	-
Dorosoma cepedianum	9	-	-	-
Menidia beryllina	2	-	-	-

Appendix 2: **Fish Abundance and Sizes by Waterways, 1993-1994. (continued)**

------------------------------LOCATION=Ab ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	2	-	-	-
Anguilla rostrata	8	-	-	-
Cyprinella spiloptera	19	-	-	-
Semotilus atromaculatus	4	-	-	-
Fundulus diaphanus	2	-	-	-
Hybognathus regius	32	-	-	-
Etheostoma olmstedi	8	-	-	-
Catostomus commersoni	6	-	-	-
Luxilus cornutus	31	-	-	-
Ameiurus nebulosus	1	-	-	-
Notropis procne	21	-	-	-
Semotilus corporalis	6	-	-	-
Rhinichthys cataractae	1	-	-	-
Lepomis auritus	2	-	-	-
Micropterus salmoides	2	-	-	-

------------------------------LOCATION=Ae ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	4	4.03	3.1	5
Lepomis macrochirus	5	9	6.5	15.6
Anguilla rostrata	24	27.7	12	60
Fundulus diaphanus	1	8.5	8.5	8.5
Etheostoma olmstedi	37	4.85	3	8
Lepomis gibbosus	9	11.9	7.8	16
Hypentelium nigricans	35	4.07	3	7
Ameiurus nebulosus	9	9.62	3.5	19.5
Notropis procne	17	8.08	4.5	10.5
Semotilus corporalis	17	8.98	7	11
Notropis bifrenatus	30	15.2	1.5	7.6
Exoglossum maxillingua	1	7	7	7
Rhinichthys cataractae	54	5.53	3.2	8.2
Cyprinus carpio	2	-	-	-

------------------------------LOCATION=Db ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	12	-	-	-
Anguilla rostrata	1	-	-	-
Fundulus diaphanus	1	-	-	-
Luxilus cornutus	5	-	-	-
Lepomis gibbosus	15	-	-	-
Ameiurus nebulosus	4	-	-	-
Carassius auratus	1	-	-	-
Lepomis auritus	4	-	-	-
Notropis hudsonius	6	-	-	-
Enneacanthus gloriosus	2	-	-	-

Appendix 2: Fish Abundance and Sizes by Waterways, 1993-1994. (continued)

------------------------------LOCATION=Af ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	11	3.93	3	5.5
Lepomis macrochirus	4	9.38	6.5	15.5
Anguilla rostrata	15	24.5	7	40
Cyprinella spiloptera	71	5.43	3	6.5
Gambusia holbrooki	2	4.75	4.5	5
Semotilus atromaculatus	6	8.17	4	16.5
Erimyzon oblongus	1	9.7	9.7	9.7
Lepomis cyanellus	2	10.5	10.4	10.5
Etheostoma olmstedi	32	4.28	2	6.5
Pimephales notatus	151	4.83	2.7	6.8
Catostomus commersoni	60	6.4	2	16.6
Micropterus dolomieu	2	6.6	6	7.2
Lepomis gibbosus	4	9.08	7.5	10.2
Hypentelium nigricans	78	5.85	3.2	10.5
Ameiurus nebulosus	15	6.73	3.5	15
Notropis procne	16	8.36	5	11.5
Notemigonus crysoleucas	14	7.1	5.4	10
Semotilus corporalis	29	8.6	4	16
Notropis bifrenatus	62	5.06	2.5	6.6
Rhinichthys cataractae	33	6.28	3.2	7.8
Lepomis auritus	2	13.9	13.3	14.5
Nocomis micropogon	1	-	-	-

------------------------------LOCATION=Dc ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	42	-	-	-
Anguilla rostrata	5	-	-	-
Semotilus atromaculatus	16	-	-	-
Hybognathus regius	2	-	-	-
Etheostoma olmstedi	1	-	-	-
Lepomis gibbosus	8	-	-	-
Ameiurus nebulosus	1	-	-	-
Umbra pygmaea	1	-	-	-
Carassius auratus	1	-	-	-
Notemigonus crysoleucas	4	-	-	-
Dorosoma cepedianum	2	-	-	-
Micropterus salmoides	4	-	-	-
Ameiurus natalis	1	-	-	-
Lepomis gulosus	1	-	-	-
Lepomis megalotis	2	-	-	-

------------------------------LOCATION=Dd ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	15	-	-	-
Anguilla rostrata	6	-	-	-
Semotilus atromaculatus	5	-	-	-
Hybognathus regius	3	-	-	-
Lepomis gibbosus	1	-	-	-
Notemigonus crysoleucas	9	-	-	-
Micropterus salmoides	5	-	-	-
Ameiurus natalis	1	-	-	-

Appendix 2: Fish Abundance and Sizes by Waterways, 1993-1994. (continued)

------------------------------LOCATION=G2 ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	375	4.35	1	7.2
Lepomis macrochirus	2	5.4	5.4	5.4
Anguilla rostrata	47	22.1	10	60
Gambusia holbrooki	11	2.02	1	4.5
Semotilus atromaculatus	210	4.95	1.2	12.3
Erimyzon oblongus	14	9.59	6	11.5
Lampetra aepyptra	61	9.28	1.5	14.2
Pimephales notatus	86	4.28	2.5	6.9
Clinostomus funduloides	240	4.73	2.8	6.5
Lepomis gibbosus	1	5.2	5.2	5.2
Umbra pygmaea	161	5.15	2.4	10.1
Notemigonus crysoleucas	21	5.65	3.9	8.3
Semotilus corporalis	1	5.3	5.3	5.3

------------------------------LOCATION=G5 ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	384	4.46	1.2	7
Lepomis macrochirus	10	5.73	5	6.5
Anguilla rostrata	36	19.5	8	35
Semotilus atromaculatus	127	6.94	3.7	11.8
Fundulus diaphanus	10	5.93	5	8.7
Erimyzon oblongus	9	7.51	4	11
Clinostomus funduloides	1	5	5	5
Hypentelium nigricans	1	9.4	9.4	9.4
Ameiurus nebulosus	2	8.45	8.2	8.7
Umbra pygmaea	12	5.18	2.5	9
Fundulus heteroclitus	7	5.5	4.8	6.7
Carassius auratus	1	10.2	10.2	10.2

--------------------------LOCATION=Mulligan --------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	226	-	-	-
Anguilla rostrata	2	-	-	-
Gambusia holbrooki	2	-	-	-
Erimyzon oblongus	9	-	-	-
Etheostoma olmstedi	1	-	-	-
Lepomis gibbosus	13	-	-	-
Umbra pygmaea	2	-	-	-
Notemigonus crysoleucas	2	-	-	-
Micropterus salmoides	24	-	-	-
Pomoxis nigromaculatus	2	-	-	-
Lepomis gulosus	1	-	-	-
Lepomis megalotis	4	-	-	-

Appendix 2: Fish Abundance and Sizes by Waterways, 1993-1994. (continued)

LOCATION=Pb

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	2	-	-	-
Anguilla rostrata	1	-	-	-
Fundulus diaphanus	1	-	-	-
Notropis hudsonius	94	-	-	-
Menidia beryllina	1	-	-	-
Micropterus salmoides	2	-	-	-

LOCATION=Pc

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	4	-	-	-
Anguilla rostrata	3	-	-	-
Fundulus diaphanus	3	-	-	-
Catostomus commersoni	63	-	-	-
Micropterus dolomieu	1	-	-	-
Luxilus cornutus	111	-	-	-
Lepomis gibbosus	1	-	-	-
Ameiurus nebulosus	17	-	-	-
Carassius auratus	1	-	-	-
Exoglossum maxillingua	3	-	-	-
Notropis hudsonius	6	-	-	-
Morone americana	8	-	-	-
Pomoxis nigromaculatus	1	-	-	-
Ameiurus natalis	2	-	-	-

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994.
Analysis Variable : SIZE

-----------------------------LOCATION=A6a -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	24	3.74	2.5	6.5
Anguilla rostrata	12	16.7	10	30
Cyprinella spiloptera	6	4.67	3.3	6.5
Erimyzon oblongus	1	8	8	8
Etheostoma olmstedi	1	5.5	5.5	5.5

-----------------------------LOCATION=A6b -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	62	4.75	3.5	6.5
Anguilla rostrata	6	25	12	50
Cyprinella spiloptera	29	6.56	3.5	12
Erimyzon oblongus	1	7.5	7.5	7.5
Lepomis cyanellus	1	10	10	10
Pimephales notatus	2	6.35	5.5	7.2
Etheostoma olmstedi	7	6.41	5.5	7
Clinostomus funduloides	4	10.7	3.8	17
Hypentelium nigricans	2	7.65	7.5	7.8

-----------------------------LOCATION=A6c -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	58	4.94	3.2	6
Lepomis macrochirus	2	5.5	5	6
Anguilla rostrata	1	12	12	12
Cyprinella spiloptera	29	6.84	2.5	40
Erimyzon oblongus	16	11.3	5.8	18.5
Clinostomus funduloides	11	5.96	5.5	6.5
Hypentelium nigricans	4	7.25	5.5	9.5
Umbra pygmaea	6	5.17	4.5	7

-----------------------------LOCATION=A6d -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	91	4.61	2	6
Lepomis macrochirus	1	13.5	13.5	13.5
Anguilla rostrata	3	30.7	10	52
Cyprinella spiloptera	50	5.68	3.5	14.4
Erimyzon oblongus	7	14.4	11	18.5
Etheostoma olmstedi	2	5.5	5.5	5.5
Pimephales notatus	2	4.75	4.5	5
Clinostomus funduloides	7	5.71	3.5	8.8
Notropis procne	1	11.5	11.5	11.5

Appendix 3: **Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)**

-----------------------------LOCATION=A6e -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	84	4.8	3	7.5
Anguilla rostrata	1	53	53	53
Cyprinella spiloptera	55	8.23	3	73
Clinostomus funduloides	8	5.63	3.5	7
Hypentelium nigricans	2	12.8	11	14.5

-----------------------------LOCATION=A6f -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	54	4.88	3.5	6
Anguilla rostrata	1	27	27	27
Cyprinella spiloptera	2	6.75	5.5	8
Semotilus atromaculatus	20	8.68	4	15
Clinostomus funduloides	10	5.72	4.3	7.2
Hypentelium nigricans	3	10	8	12.5

-----------------------------LOCATION=A6g -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	58	4.71	3	6.5
Anguilla rostrata	5	21.6	13	28
Semotilus atromaculatus	25	7.15	3.8	15.2
Clinostomus funduloides	5	5.7	5.5	6.5

-----------------------------LOCATION=A6h -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	47	4.53	3	6.5
Anguilla rostrata	6	24.7	14	50
Semotilus atromaculatus	25	7.41	3.2	14.5
Clinostomus funduloides	6	7.05	5.5	10.8
Hypentelium nigricans	3	10.5	10	11

-----------------------------LOCATION=A6i -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	20	4.53	3	5.8
Lepomis macrochirus	1	5.3	5.3	5.3
Semotilus atromaculatus	29	8.34	3.5	19
Clinostomus funduloides	11	5.74	4	7
Hypentelium nigricans	5	11.2	10.2	12
Umbra pygmaea	1	8	8	8

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

-----------------------------LOCATION=A6j -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	67	4.41	2.8	6.5
Anguilla rostrata	2	18.5	11	26
Semotilus atromaculatus	26	8.18	3	13
Clinostomus funduloides	17	6.18	5.2	7.5
Hypentelium nigricans	3	13	11.5	15.5

-----------------------------LOCATION=A6k -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	96	4.46	2.2	6.3
Anguilla rostrata	5	17.4	10	23
Semotilus atromaculatus	33	8.18	2.5	14.5
Clinostomus funduloides	28	5.6	4	8

-----------------------------LOCATION=A6l -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	196	4.4	4.4	4.4
Semotilus atromaculatus	27	6.68	4.7	9.1

----------------------------LOCATION=A6m -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	300	4.4	4.4	4.4
Anguilla rostrata	1	45	45	45
Semotilus atromaculatus	29	8.07	5.5	11.5

-----------------------------LOCATION=A6n -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	60	4.4	4.4	4.4
Semotilus atromaculatus	9	8.62	5.8	10.5

-----------------------------LOCATION=A13a -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	2	4	3.5	4.5
Anguilla rostrata	4	14.3	10	16
Semotilus atromaculatus	2	7.5	6.5	8.5
Fundulus diaphanus	1	5.5	5.5	5.5
Etheostoma olmstedi	4	5.63	4.5	7

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

----------------------------LOCATION=A13b -------------------------------

Species	N Obs	Mean	Min	Max	
Rhinichthys atratulus	5	5.9	5.5	6.5	
Lepomis macrochirus	1	4.5	4.5	4.5	
Cyprinella spiloptera	2	8.35	8.2	8.5	
Umbra pygmaea		3	6.67	5	7.5

----------------------------LOCATION=A15a -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	278	3.85	1	7
Lepomis macrochirus	56	4.7	2.5	9
Anguilla rostrata	3	19	15	27
Cyprinella spiloptera	44	4.09	2.5	7
Gambusia holbrooki	10	2.95	2.5	3.5
Semotilus atromaculatus	34	7.12	3	15
Fundulus diaphanus	16	4.41	3.5	6
Erimyzon oblongus	4	4.38	3.5	5
Lepomis cyanellus	1	8	8	8
Hybognathus regius	33	4.15	2.5	6
Etheostoma olmstedi	3	5.33	5	5.5
Lampetra aepyptra	1	12.5	12.5	12.5

----------------------------LOCATION=A15b -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	72	4.23	2	6.5
Lepomis macrochirus	30	5.08	4	6
Anguilla rostrata	2	23.5	22	25
Semotilus atromaculatus	15	9.5	5	17
Erimyzon oblongus	1	9.5	9.5	9.5
Hybognathus regius	12	5.38	4	7.5
Clinostomus funduloides	2	6	5.5	6.5

----------------------------LOCATION=A15c -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	47	4.52	2.5	6
Lepomis macrochirus	21	4.76	4	6
Anguilla rostrata	3	25.7	22	30
Semotilus atromaculatus	12	10.2	6.5	18
Lepomis cyanellus	4	8	5	10.5
Hybognathus regius	2	5.5	5.5	5.5
Clinostomus funduloides	10	6.6	5	9.5

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

-----------------------------LOCATION=A15d -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	71	4.16	1.5	5.5
Lepomis macrochirus	11	4.95	4	6.5
Semotilus atromaculatus	9	9	4.5	15.5
Lepomis cyanellus	1	3.5	3.5	3.5
Hybognathus regius	3	6.33	5	8
Clinostomus funduloides	5	7.7	7	9
Catostomus commersoni	1	9.5	9.5	9.5

-----------------------------LOCATION=A15e -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	71	4.4	2	7
Lepomis macrochirus	17	5.35	4.5	9
Anguilla rostrata	2	19	15	23
Semotilus atromaculatus	11	7.95	6	12
Hybognathus regius	6	6.42	5	9
Clinostomus funduloides	9	6.22	5	8

-----------------------------LOCATION=A15f -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	110	4.39	2	6.5
Lepomis macrochirus	41	5.28	4.5	7
Anguilla rostrata	4	23.8	10	32
Semotilus atromaculatus	7	8.36	5	15.5
Erimyzon oblongus	2	13.8	12.5	15
Lepomis cyanellus	2	11	9.5	12.5
Clinostomus funduloides	7	6.5	5.5	8.5
Micropterus dolomieu	1	8.5	8.5	8.5
Luxilus cornutus	11	7.73	5.5	10.5
Lepomis gibbosus	1	13.5	13.5	13.5

-----------------------------LOCATION=A15g -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	152	4.46	1.5	7.5
Anguilla rostrata	2	25	22	28
Micropterus dolomieu	1	6	6	6

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

------------------------------LOCATION=A16a ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	37	4.42	2.5	5.5
Lepomis macrochirus	7	4.93	4	6
Anguilla rostrata	1	11	11	11
Cyprinella spiloptera	29	4.62	3	6.5
Fundulus diaphanus	65	4.84	3.5	7.5
Lepomis gibbosus	1	6.5	6.5	6.5
Hypentelium nigricans	1	5.5	5.5	5.5

------------------------------LOCATION=A19a ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	13	3.54	2.8	4.3
Cyprinella spiloptera	57	4.06	2.7	5.8
Fundulus diaphanus	28	5.81	3.4	7.8
Hybognathus regius	8	3.94	2.7	5.4
Etheostoma olmstedi	12	4.02	2	5.6
Notropis hudsonius	200	3.9	2	5.5

------------------------------LOCATION=A19b ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	6	4.38	3	6.8
Lepomis macrochirus	1	11.2	11.2	11.2
Cyprinella spiloptera	24	4.4	3.5	5.6
Fundulus diaphanus	22	6.09	4.4	9
Hybognathus regius	8	4.59	3.8	5.7
Etheostoma olmstedi	2	4.15	3.8	4.5
Notropis hudsonius	202	4.61	3	5.8

------------------------------LOCATION=A19c ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	12	3.94	2.5	5
Lepomis macrochirus	5	7.46	4.8	12
Anguilla rostrata	1	12.5	12.5	12.5
Cyprinella spiloptera	60	4.49	3.1	6.5
Semotilus atromaculatus	1	9.1	9.1	9.1
Fundulus diaphanus	106	5.96	4	9
Hybognathus regius	1	4.8	4.8	4.8
Etheostoma olmstedi	7	5.36	3.5	6.8
Luxilus cornutus	1	10.3	10.3	10.3
Hypentelium nigricans	1	8.5	8.5	8.5
Notropis hudsonius	325	4.47	2.3	6.9

Appendix 3: **Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)**

------------------------------LOCATION=A19d ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	2	3.6	3.4	3.8
Lepomis macrochirus	5	6.86	3.4	9.3
Anguilla rostrata	3	33.3	25	40
Cyprinella spiloptera	34	4.95	3.4	8.6
Fundulus diaphanus	140	6.5	4	8.8
Hybognathus regius	2	7.45	6	8.9
Etheostoma olmstedi	4	4.78	3.7	6.7
Catostomus commersoni	4	18.3	5.5	38
Luxilus cornutus	14	8.43	5.5	14.5
Ameiurus nebulosus	2	11.7	7.4	16
Notropis hudsonius	133	4.77	2.4	8.6

------------------------------LOCATION=Aa ------------------------------

Species	N Obs	Mean	Min	Max
Semotilus atromaculatus	1	6.8	-	-
Fundulus diaphanus	112	5.9	-	-
Hybognathus regius	19	4.8	-	-
Etheostoma olmstedi	12	4.9	-	-
Catostomus commersoni	18	7.2	-	-
Luxilus cornutus	29	8.2	-	-
Lepomis gibbosus	2	10.3	-	-
Notropis procne	63	6.2	-	-
Notemigonus crysoleucas	2	4.4	-	-
Notropis hudsonius	6	7.16	-	-
Morone americana	10	-	-	-
Perca flavescens	2	-	-	-
Dorosoma cepedianum	9	-	-	-
Menidia beryllina	2	-	-	-

------------------------------LOCATION=Ab ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	2	5.4	-	-
Anguilla rostrata	8	22.5	-	-
Cyprinella spiloptera	19	9	-	-
Semotilus atromaculatus	4	6.8	-	-
Fundulus diaphanus	2	5.9	-	-
Hybognathus regius	32	4.8	-	-
Etheostoma olmstedi	8	4.9	-	-
Catostomus commersoni	6	7.2	-	-
Luxilus cornutus	31	8.2	-	-
Ameiurus nebulosus	1	8.1	-	-
Notropis procne	21	8.3	-	-
Semotilus corporalis	6	8.7	-	-
Rhinichthys cataractae	1	5.8	-	-
Lepomis auritus	2	13.9	-	-
Micropterus salmoides	2	-	-	-

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

-----------------------------LOCATION=Ae8 -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	2	4.75	4.5	5
Lepomis macrochirus	3	10.3	7.6	15.6
Anguilla rostrata	17	27.8	12	60
Fundulus diaphanus	1	8.5	8.5	8.5
Etheostoma olmstedi	30	4.91	3	8
Lepomis gibbosus	8	12.1	7.8	16
Hypentelium nigricans	30	3.77	3	7
Ameiurus nebulosus	3	16.2	12	19.5
Notropis procne	17	8.08	4.5	10.5
Semotilus corporalis	14	8.58	7	11
Notropis bifrenatus	239	5.23	1.5	7.6
Rhinichthys cataractae	53	5.52	3.2	8.2

-----------------------------LOCATION=Ae9 -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	2	3.3	3.1	3.5
Lepomis macrochirus	2	7	6.5	7.5
Anguilla rostrata	7	27.4	19	39
Etheostoma olmstedi	7	4.61	3.7	6
Lepomis gibbosus	1	10.5	10.5	10.5
Hypentelium nigricans	5	5.88	3.8	7
Ameiurus nebulosus	6	6.35	3.5	12.5
Semotilus corporalis	3	10.8	10.5	11
Notropis bifrenatus	62	5.1	2.8	7.2
Exoglossum maxillingua	1	7	7	7
Rhinichthys cataractae	1	6	6	6
Cyprinus carpio	2	-	-	-

-----------------------------LOCATION=Af1 -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	7	3.46	3	4.3
Lepomis macrochirus	4	9.38	6.5	15.5
Anguilla rostrata	10	21.7	7	33.5
Cyprinella spiloptera	71	5.43	3	6.5
Gambusia holbrooki	2	4.75	4.5	5
Semotilus atromaculatus	6	8.17	4	16.5
Etheostoma olmstedi	28	4.23	2	6.5
Pimephales notatus	151	4.83	2.7	6.8
Lepomis gibbosus	2	9.6	9	10.2
Hypentelium nigricans	77	5.87	3.2	10.5
Ameiurus nebulosus	12	6.38	3.5	11.3
Notropis procne	16	8.36	5	11.5
Notemigonus crysoleucas	14	7.1	5.4	10
Semotilus corporalis	15	7.67	4	11
Nocomis micropogon	1	-	-	-

-----------------------------LOCATION=Af2 --------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	4	4.75	4	5.5
Anguilla rostrata	5	30.3	15.5	40
Erimyzon oblongus	1	9.7	9.7	9.7
Lepomis cyanellus	2	10.5	10.4	10.5
Etheostoma olmstedi	4	4.65	3	5.8
Catostomus commersoni	60	6.4	2	16.6
Micropterus dolomieu	2	6.6	6	7.2
Lepomis gibbosus	2	8.55	7.5	9.6
Hypentelium nigricans	1	4.6	4.6	4.6
Ameiurus nebulosus	3	8.17	4.5	15
Semotilus corporalis	14	9.59	7.5	16
Notropis bifrenatus	62	5.06	2.5	6.6
Rhinichthys cataractae	33	6.28	3.2	7.8
Lepomis auritus	2	13.9	13.3	14.5

------------------------------LOCATION=Db --------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	12	5.4	-	-
Anguilla rostrata	1	22.5	-	-
Fundulus diaphanus	1	5.9	-	-
Luxilus cornutus	5	8.2	-	-
Lepomis gibbosus	15	10.6	-	-
Ameiurus nebulosus	4	8.1	-	-
Carassius auratus	1	10.2	-	-
Lepomis auritus	4	13.9	-	-
Notropis hudsonius	6	4.4	-	-
Enneacanthus gloriosus	2	-	-	-

-----------------------------LOCATION=Dc --------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	42	5.4	-	-
Anguilla rostrata	5	22.5	-	-
Semotilus atromaculatus	16	6.8	-	-
Hybognathus regius	2	4.8	-	-
Etheostoma olmstedi	1	4.9	-	-
Lepomis gibbosus	8	10.6	-	-
Ameiurus nebulosus	1	8.1	-	-
Umbra pygmaea	1	5.2	-	-
Carassius auratus	1	10.2	-	-
Notemigonus crysoleucas	4	6.2	-	-
Dorosoma cepedianum	2	-	-	-
Micropterus salmoides	4	-	-	-
Ameiurus natalis	1	-	-	-
Lepomis gulosus	1	-	-	-
Lepomis megalotis	2	-	-	-

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

------------------------------LOCATION=Dd ------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	15	5.4	-	-
Anguilla rostrata	6	22.5	-	-
Semotilus atromaculatus	5	6.8	-	-
Hybognathus regius	3	4.8	-	-
Lepomis gibbosus	1	10.6	-	-
Notemigonus crysoleucas	9	6.2	-	-
Micropterus salmoides	5	-	-	-
Ameiurus natalis	1	-	-	-

------------------------------LOCATION=G2a ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	1	4.7	-	-
Lepomis macrochirus	1	5.4	-	-
Gambusia holbrooki	2	4.5	-	-
Semotilus atromaculatus	12	4.9	4	7.5
Pimephales notatus	25	4.16	3.5	5.2
Clinostomus funduloides	2	4.85	4.4	5.3
Lepomis gibbosus	1	5.2	5.2	5.2
Umbra pygmaea	10	4.51	3	6.4

------------------------------LOCATION=G2b ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	12	3.91	2	5
Lepomis macrochirus	1	5.4	5.4	5.4
Anguilla rostrata	3	36.7	20	60
Gambusia holbrooki	9	1.47	1	2
Semotilus atromaculatus	1	10.1	10.1	10.1
Erimyzon oblongus	5	9.04	6.5	10.4
Pimephales notatus	38	4.46	2.5	6.9
Clinostomus funduloides	40	4.64	2.8	6.5
Umbra pygmaea	80	5.08	2.4	10.1
Notemigonus crysoleucas	20	5.6	3.9	8.3
Semotilus corporalis	1	5.3	5.3	5.3

------------------------------LOCATION=G2c ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	49	4.59	1.5	7.2
Anguilla rostrata	9	20.8	15	30
Semotilus atromaculatus	36	5.02	3.3	10.3
Erimyzon oblongus	6	9.42	6	11.5
Lampetra aepyptra	30	9.92	1.5	14.2
Pimephales notatus	23	4.13	3.3	5
Clinostomus funduloides	15	5.37	4.2	6.3
Umbra pygmaea	23	5.43	3	7.6

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

-----------------------------LOCATION=G2d -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	98	4.28	1.5	6.5
Anguilla rostrata	18	19.7	10	29
Semotilus atromaculatus	82	4.5	1.2	11.6
Erimyzon oblongus	3	10.8	10.5	11.2
Lampetra aepyptra	22	8.59	3.5	13
Clinostomus funduloides	54	4.63	3.5	6.1
Umbra pygmaea	27	5.21	3.1	6.6
Notemigonus crysoleucas	1	6.7	6.7	6.7

-----------------------------LOCATION=G2e -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	126	4.31	1	6.4
Anguilla rostrata	13	20	11	30.2
Semotilus atromaculatus	48	5.35	2.1	12.3
Clinostomus funduloides	60	4.8	3.3	6.4
Umbra pygmaea		10	5.48	4.2

-----------------------------LOCATION=G2f -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	89	4.43	3	7
Anguilla rostrata	4	32	23	40
Semotilus atromaculatus	31	5.31	3.2	10.6
Lampetra aepyptra	9	8.86	7	12
Clinostomus funduloides	69	4.67	3	6.5
Umbra pygmaea		11	5.15	3

-----------------------------LOCATION=G5a -------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	14	4.01	1.7	5.4
Anguilla rostrata	14	18.2	10	22
Semotilus atromaculatus	6	7.73	4.6	10.5
Fundulus diaphanus	10	5.93	5	8.7
Erimyzon oblongus	2	4.75	4	5.5
Clinostomus funduloides	1	5	5	5
Hypentelium nigricans	1	9.4	9.4	9.4
Ameiurus nebulosus	2	8.45	8.2	8.7
Umbra pygmaea	5	5.24	2.5	7.5
Fundulus heteroclitus	7	5.5	4.8	6.7
Carassius auratus	1	10.2	10.2	10.2

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

------------------------------LOCATION=G5b ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	47	4	1.5	6.4
Anguilla rostrata	5	17	9	35
Semotilus atromaculatus	31	6.23	3.7	11.8
Umbra pygmaea	5	4.6	2.5	9

------------------------------LOCATION=G5c ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	96	4.37	1.2	7
Anguilla rostrata	4	20	15	25
Semotilus atromaculatus	47	6.66	4.2	10.9
Erimyzon oblongus	1	7.5	7.5	7.5
Umbra pygmaea	2	6.45	6.4	6.5

------------------------------LOCATION=G5d ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	185	4.4	4.4	4.4
Lepomis macrochirus	10	5.73	5	6.5
Anguilla rostrata	11	20.6	8	35
Semotilus atromaculatus	37	7.42	4.1	11.3
Erimyzon oblongus	6	8.43	6.3	11

------------------------------LOCATION=G5e ------------------------------

Species	N Obs	Mean	Min	Max
Rhinichthys atratulus	42	5.61	4.5	7
Anguilla rostrata	2	27.5	25	30
Semotilus atromaculatus	6	9.07	5	11.5

----------------------------LOCATION=Mulligan ----------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	226	5.4	-	-
Anguilla rostrata	2	22.5	-	-
Gambusia holbrooki	2	2.7	-	-
Erimyzon oblongus	9	10.1	-	-
Etheostoma olmstedi	1	4.9	-	-
Lepomis gibbosus	13	10.6	-	-
Umbra pygmaea	2	5.2	-	-
Notemigonus crysoleucas	2	6.2	-	-
Micropterus salmoides	24	-	-	-
Pomoxis nigromaculatus	2	-	-	-
Lepomis gulosus	1	-	-	-
Lepomis megalotis	4	-	-	-

Appendix 3: Fish Abundance and Sizes by Collection Sites, 1993 -1994. (continued)

------------------------------LOCATION=Pb --------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	2	5.4	-	-
Anguilla rostrata	1	22.5	-	-
Fundulus diaphanus	1	5.9	-	-
Notropis hudsonius	94	4.4	-	-
Menidia beryllina	1	-	-	-
Micropterus salmoides	2	-	-	-

-----------------------------LOCATION=Pc1 -------------------------------

Species	N Obs	Mean	Min	Max
Lepomis macrochirus	4	5.4	-	-
Anguilla rostrata	3	22.5	-	-
Fundulus diaphanus	3	5.9	-	-
Catostomus commersoni	63	7.2	-	-
Micropterus dolomieu	1	6.9	-	-
Luxilus cornutus	111	8.2	-	-
Lepomis gibbosus	1	10.6	-	-
Ameiurus nebulosus	17	8.1	-	-
Carassius auratus	1	10.2	-	-
Exoglossum maxillingua	3	7	-	-
Notropis hudsonius	6	4.4	-	-
Morone americana	8	-	-	-
Pomoxis nigromaculatus	1	-	-	-
Ameiurus natalis	2	-	-	-

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When possible, manuscripts should be submitted on IBM compatible 5¼ inch high density floppy discs formatted for Word Perfect 5.0, 5.1 or other compatible software (this is particularly important with longer manuscripts). If word processing capability is not available, submit manuscripts typed, double spaced, on good quality bond paper with adequate margins. Authors should adhere generally to the *Council of Biology Editors Style Manual*. However, individuality and readability of writing style are encouraged.

Contributions other than short notes may include a brief informative abstract. Payment of page charges is not required for publication in *The Maryland Naturalist*. However, if funds are available, assistance to offset publication costs would be welcome.

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NATURAL HISTORY SOCIETY OF MARYLAND, INC.
2643 North Charles Street
Baltimore, Maryland 21218

The Maryland Naturalist

The Natural History Society of Maryland

Volume 40, Number 1-4 Jan./Dec. 1996

ISSN 0096-4158

The Maryland Naturalist

Volume 40, Number 1-4 Jan./Dec. 1996

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: April 15, 1997

Cover Illustration: Mating European garden slugs, *Limax maximus*. This large (100 mm) introduced slug is now common around residences throughout much of the eastern United States. Copulation occurs in mid-air, as mating individuals hang intertwined, suspended by a thick strand of mucus. The large, pale mass below these slugs is the joined reproductive organs, which, although normally internal, are extended from the body cavity for copulation. Actual copulation takes 5 to 10 minutes, and typically occurs at night. From a 35 mm slide taken by Luther C. Goldman at College Park, Maryland.

Additions to the Flora of Cranberry Swamp, Finzel, Maryland

Simon Dabydeen and Thad E. Yorks

ABSTRACT. Cranberry Swamp in Garrett and Allegany County, Maryland is a floristically diverse site protected by The Nature Conservancy. Many plant species exist at Cranberry Swamp as relict populations, and have geographic distributions extending far to the north (New England, Canada). Fourteen previously unrecorded species have been identified at the swamp.

Cranberry Swamp, also known as Finzel Swamp, is located at the headwaters of the Savage River west of Savage Mountain on the Garrett-Allegany County line in Maryland. Topographically, the swamp has an elevation of 823 m (2700 feet) and is in a shallow depression where average temperatures are lower than much of the surrounding area, resulting in relatively cool summers and cold winters. The swamp is considered a frost pocket, creating a microclimate that is boreal in nature. Floristically, the swamp is diverse and supports many species with typically northern (New England, Canada) geographical distributions, such as *Calla palustris* (Wild Calla) and *Larix laricina* (American Larch or Tamarack). It is thought that these northern species became established at Cranberry Swamp before the end of the last Pleistocene glacial advance approximately 20,000 years ago, and remained as relict populations after the glaciers receded and temperatures rose (Brown 1982). The area now functions as a refugium and is unique in its floristic composition.

Brown (1982) conducted a vegetation survey of Cranberry Swamp and its surrounding areas and identified 281 vascular plant species representing 184 genera and 68 families. During the last four years, botanical forays into the same areas have led to the discovery of 14 unrecorded taxa. These additional species are listed in Table 1. Nomenclature follows Brown and Brown (1972, 1984).

Table 1 Additions to the flora of Cranberry Swamp, Finzel, Maryland

Scientific name	Common name	Family
Antennaria neglecta Green	Field pussytoes	Asteraceae
Calamagrostis canadensis (Michx.) Beauv.	Reed-bentgrass	Poaceae
Carex lacustris Willd.	Sedge	Cyperaceae
Conopholis americana (L.) Wallr.	Squawroot	Orobanchaceae
Cornus racemosa Lam.	Paniculate dogwood or gray-stemmed dogwood	Cornaceae
Epifagus virginiana (L.) Bart.	Beechdrops	Orobanchaceae
Isoetes engelmanni A. Br.	Engelmann's quillwort	Isoetaceae
Matricaria matricarioides (Less.) Porter	Pineapple weed	Asteraceae
Melilotus officinalis (L.) Lam.	Yellow sweet clover	Fabaceae
Pyrus arbutifolia (L.) L. f.	Red chokeberry	Rosaceae
Sambucus pubens Michx.	Red-berried elder	Caprifoliaceae
Senecio aureus L.	Golden ragwort	Asteraceae
Sisyrinchium mucronatum Michx.	Slender blue-eyed grass	Iridaceae
Trillium undulatum Willd.	Painted trillium	Liliaceae

A revised floristic checklist for Cranberry Swamp should now include 285 species, representing 190 genera (new genera are *Calamagrostis*, *Matricaria*, *Conopholis*, *Epifagus*, *Isoetes*, and *Sisyrinchium*) and 70 families (new families are Isoetaceae and Iridaceae). Most of these species are represented by small populations or only a few individuals. However, *Carex lacustris*, a threatened species with both sexual and vegetative reproductive strategies, forms a large and vigorously expanding population. It is worth mentioning that in recent years a disastrous decline has been observed in once viable populations of dominant 'keystone' tree species, such as *Nyssa sylvatica* (Black Gum) and *Larix laricina*. Very little *L. laricina* regeneration is occurring at Cranberry Swamp, and this species may be near extirpation. Conversely, populations of many other species have remained stable or increased in size, as observed in *Sanguisorba canadensis* (Canadian Burnet) and *Calla palustris*.

Some have suggested that these changes in vegetation are the result of natural evolutionary processes, but others have argued that accelerated rates of change may be attributed to increased human activities. It is likely that changes in species diversity and abundance at the Cranberry Swamp have been, and will continue to be, influenced by at least two anthropogenic factors; 1) construction of a road which divides the swamp into two sections and alters hydrologic relationships, and 2) creation of labyrinthine footpaths within the swamp by hikers and berry-pickers.

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A Brief Survey of Maryland Cychrini (Coleoptera: Carabidae)

John Glaser

Beetles of the carabid tribe Cychrini have held the fascination of amateurs and professional coleopterists alike over the years, in part because many of the species are large and showy, but also because they are biologically interesting. Cychrini are characterized by much elongated heads, mandibles, and in many species a small cordate pronotum, superbly adapted for insertion into snail shells and feeding upon the occupants. The beetles are nocturnal and are generally encountered prowling about in rocky areas, on tree trunks, or on the forest floor, searching for snails and other prey. During daylight hours, like most carabids, they secrete themselves under rocks or other ground cover, behind loose bark, or under the moss carpet on the forest floor.

Cychrini, excepting some *Sphaeroderus*, have always been relatively scarce insects in collections. Successful diurnal collecting has generally involved moving a great deal of ground cover to secure few specimens. The advent, in recent years, of the widespread use of unbaited pitfall traps has shown that sizable series of these beetles can be taken with relative ease. The simplest type of pitfall, a plastic cup sunk to its lip in the soil and containing an inch or so of ethylene glycol or vinegar, works well in areas where Cychrini are known or suspected to be present, especially if it is supplemented with a barrier to guide foraging beetles into the trap. If the cups are to be left in the field for several weeks to a month, a rain shield such as a large flat rock propped over each cup is useful to avoid flooding. A series of traps at a favorable site will often yield numbers of cychrines and are an excellent guide to species present in any given area. The use of pitfalls by myself and other coleopterists, supplemented by turning much ground cover over the past decade or so, has produced a good preliminary estimate of the species present in Maryland and their distribution within the State.

The current view of cychrine taxonomy (Bousquet and Larochelle 1993, Downie and Arnett 1996) places the Maryland species in two genera: *Scaphinotus* and *Sphaeroderus*. Six species of *Scaphinotus* have been found in Maryland, and one other species probably occurs in the state but has not yet been collected here. *Sphaeroderus* is represented by four species or subspecies. Cychrines are flightless and tend to form local races founded on sculpture, color, and body proportions. Characteristics common to all local Cychrini are the elongated head and mandibles, in most forms a relatively narrow pronotum, expanded bulbous elytra, and black or brown base color generally overlaid with metallic purple, blue, green, or coppery iridescence. The beetles range in length from 8 to 33 mm. The cychrines discussed in this paper are illustrated in Figure 1.

Scaphinotus elevatus elevatus (Fab.) and *S. unicolor shoemakeri* Leng are essentially inhabitants of lowland forest in Maryland. Both species have striking metallic purple, blue, or coppery elytra and are distinct from other Maryland Cychrini in possessing a broad cup-shaped pronotum. *Scaphinotus unicolor* is larger (25-29 mm) than *S. elevatus* (15-23 mm), and has coarser pronotal punctuation. These beetles are uncommon in collections generally, and in my experience are rarely taken in pitfall traps. They are most likely to be encountered in floodplain forests and other locally damp woodland. *Scaphinotus unicolor* is essentially southeastern in distribution, probably reaching its northern limit on the Maryland coastal plain, but *S. elevatus* ranges more widely in the state, although most Maryland records are from the coastal plain and piedmont. My most westerly record is a specimen from the Valley and Ridge province at Rocky Gap in Allegany County. It apparently does not occur on the Appalachian Plateau.

Scaphinotus andrewsi Linn. and *S. ridingsi* Bland are closely related, wide-ranging species in the Appalachians, characterized chiefly by small cordate pronota and long legs, which were formerly grouped in the subgenus *Steniridia*. *Scaphinotus (Steniridia) andrewsi*, which ranges from Pennsylvania to

Georgia, is a relatively large species (20-27 mm) with bright purple or blue elytra, represented in Maryland by the subspecies *mutabilis* (Casey). It is commonly taken in pitfall traps set on rocky slopes or mountain crests in Garrett County, and can also be taken by overturning flat rocks or searching at night with a headlamp in such areas. Its range in Maryland apparently does not extend east of the Allegheny Front. *Scaphinotus ridingsi*, our second member of this subgenus, is smaller (16-20 mm), colored similarly to *andrewsi*, but with smoother-appearing, less deeply striate elytra. This cychrine has similar habits, and is commonly taken with *andrewsi* in Garrett County pitfalls. I have not collected it east of the Allegheny Front, despite extensive trapping throughout the rest of western Maryland. A historic population of nominate *S. ridingsi* exists (or existed) at Great Falls near D.C. (Erwin, 1981), so the species may be scattered along the Potomac valley in isolated populations. The Garrett County race of *ridingsi* is close to *monongheliae* Leng, described from Uniontown, Pennsylvania, but this assessment is problematic. The entire range of *ridingsi* is greater and more continuous than first thought, hence there may be greater racial complexity than currently recognized.

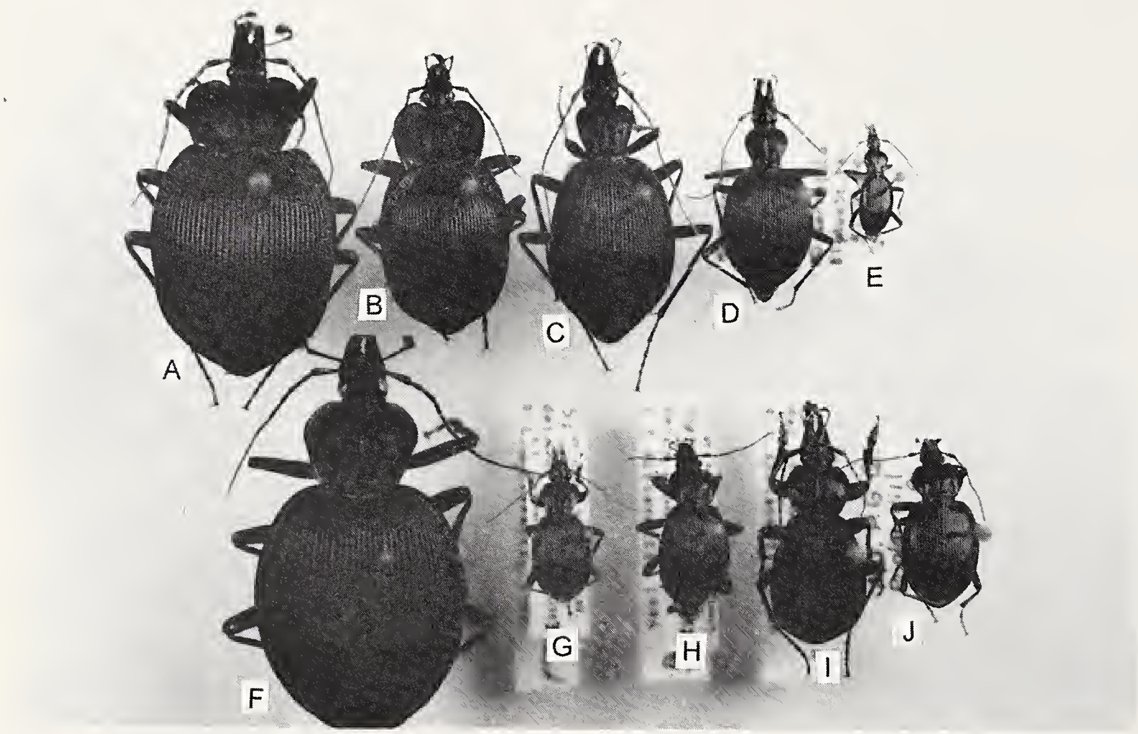

Figure 1. Maryland Cychrini: A, *Scaphinotus unicolor*; B, *Scaphinotus elevatus*; C, *Scaphinotus andrewsi*; D, *Scaphinotus ridingsi*; E, *Scaphinotus imperfectus*; F, *Scaphinotus viduus*; G, *Sphaeroderus canadensis*; H, *Sphaeroderus stenostomus lecontei*; I, *Sphaeroderus schaumi*; J, *Sphaeroderus stenostomus stenostomus*.

Scaphinotus (Maronetus) imperfectus (Horn) differs considerably from the other members of the genus. It is much smaller (8-10 mm) and shining black with brownish appendages, but shares the elongated head and cordate pronotum of the typical cychrine model. *Scaphinotus imperfectus* is relatively common in pitfall traps in Garrett County, but has not been captured eastward in Maryland. The species appears confined to the moist forests of the Appalachian Plateau.

The sixth Maryland *Scaphinotus* is *viduus* (Dejean), a large (26-33 mm) robust species with a broad cordate dark-bluish pronotum and much broader, very convex, purple elytra, varying to cupreous in some examples. *Scaphinotus viduus* ranges throughout the northeastern U.S., extending south to northern Virginia (Barr, in litt.). It is a relatively scarce insect, but exhibits a greater habitat tolerance than most other *Scaphinotus*, occurring in the dry ridgetop forests of Allegany County and in piedmont oak-hickory woodland, as well as the aforementioned Appalachian moist forests. In Maryland, the species has been collected from Garrett County east to the Baltimore-Washington area, but I have seen no records from the coastal plain. The recently described *Scaphinotus webbi* Bell is known from Pennsylvania, Virginia, and West Virginia, and probably will be found in Maryland as well with further collecting. It resembles *viduus* in size, color, and gross morphology; however, *webbi* has wider, explanate pronotal margins approaching those of *S. unicolor* and *elevatus*.

The cychrine genus *Sphaeroderus* is represented in Maryland by four taxa: *canadensis canadensis* Chaudoir, *stenostomus stenostomus* (Weber), *stenostomus lecontei* Dejean, and *schaumi* Chaudoir. All are relatively small beetles, 10-20 mm in length, typically overlain with violet or cupreous as in *Scaphinotus*, and adhering to the basic cychrine model of elongate head, small pronotum, and deeply striate inflated elytra. *Sphaeroderus canadensis* is the smallest and most narrow species of the genus, ranging from 10 to 13 mm in length, with relatively smooth, even elytral intervals. It can be recognized by its yellow-brown tarsi and palpi, appendages which are dark-brown to black in the other species of the group. In Maryland, *S. canadensis* is distributed mostly, if not entirely, in the plateau portion of western Maryland. *Sphaeroderus stenostomus lecontei* is larger, 12-16 mm in length, with wider elytra showing broken intervals over the posterior half. In addition, the elytra of *S. s. lecontei* exhibit weaker violaceous reflections than its cogeners. This taxa, like *canadensis*, appears confined to the far western part of the state. Nominate *S. stenostomus* differs most obviously from *S. s. lecontei* in having conspicuously broken strial intervals only at the apex of the elytra, resulting in a distinctly smoother appearance. Further, it has been collected over most of Maryland, including the coastal plain, but is absent on the Appalachian Plateau in Garrett County where *S. s. lecontei* is found. Our fourth Maryland *Sphaeroderus* is *schaumi*, by far the rarest member of the genus. This species is easily recognized by large size, 16-20 mm, with strial intervals widely broken over the entire elytra, reducing them to tubercles. Although known from local populations in West Virginia and Virginia for some time, *S. schaumi* has only recently been discovered in Garrett County (Bailey et al. 1994).

Further collecting, especially with pitfall traps, may expand the known range of some of these cychrine beetles within the state, but it is doubtful that any additional species (other than *S. webbi*) will be added to our fauna.

Thanks are due to Robert Acciavatti of the U.S. Forest Service, Morgantown, West Virginia for reviewing this manuscript and for fruitful discussions regarding these interesting beetles. I have also drawn upon correspondence with Thomas C. Barr, University of Kentucky, for data on cychrine distribution.

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The Distribution, Ecology and Conservation Needs of Bog Turtles, with Special Emphasis on Maryland

David S. Lee and Arnold W. Norden

Introduction

Although the bog turtle, *Clemmys muhlenbergii*, was described at the beginning of the 19th Century (Schoepff 1801), basic ecological requirements were only recognized in the past several decades and its distribution is still being defined. Bog turtles were unknown from Maryland until 1941 (McCauley and Mansueti 1944) and the majority of known sites of occurrence in the state were not located until the 1980's.

The lack of successful field work on this species prior to the 1980's is not unique to Maryland. In Virginia, bog turtles were reported as early as 1924 (Brady 1924), but that record was based on an incorrectly identified juvenile wood turtle, *Clemmys insculpta*. Barton (1960) reassessed the situation in Virginia and demonstrated that there was no valid evidence of its occurrence there. Hutchison (1963) provided the first authentic evidence for Virginia, and presently it is known from numerous sites in four counties (Herman and Tryon 1993). The species was not recorded from Georgia until 1980, South Carolina until 1982, and Tennessee until 1986 (Hale and Harris 1980, Herman and Putnam 1982, Herman and Putnam 1983, Herman and Warner 1986). New colonies are still being discovered in Pennsylvania (Hulse and Hulse 1992), New Jersey (Arndt 1986), Delaware (Arndt 1977), North Carolina, Virginia, and Georgia (Dennis Herman, pers. comm.). While the species has been known to exist in the mountains of North Carolina since the 1880's (Yarrow 1882, Dunn 1917), its actual distribution in the mountain and piedmont regions was slow to be documented. Herman (1994) reported 99 records in 18 North Carolina counties, including a 1991 record in the North Carolina piedmont, 100 miles outside of its previously known range. Herman et al. (1993) showed that the species was more broadly distributed in North Carolina than had been previously recognized.

Now that the distribution of this species is generally understood, it is apparent that there are major gaps in its overall range (Figure 1), suggesting that at one time the bog turtle was much more common and widespread than today. A hiatus of 250 miles occurs between the closest known Maryland and Virginia localities. The core of the range is an area encompassing eastern Pennsylvania, the upper piedmont of Maryland and Delaware, and running north through New Jersey, eastern New York and western Connecticut. There is also a record from Rhode Island (Babcock 1917), and there are disjunct populations in northwestern New York, northwestern Pennsylvania, the southern Appalachians, and the North Carolina piedmont.

This fragmented broad scale geographic distribution is difficult to explain with current zoogeographical information, but it is clearly a result of Pleistocene events. The disjunct micro-distribution (by county or drainage system) is apparently the result of limited habitat availability coupled with the species' need for certain early successional wetland communities. This species' disjunct (macro-distribution) and patchy occurrence (micro-distribution) indicate that its overall range has been contracting. As will be shown, this decline is partly natural, and partly a result of human disturbance, while the macro-distribution is a result of Pleistocene and post-Pleistocene climatic changes.

For biological information on the bog turtle see Barton and Price (1955), Ernst and Barbour (1972), Ernst and Bury (1977), Holub and Bloomer (1977), Bury (1979), and Ernst et al. (1994). Tryon and Herman (1990) and Herman and Tryon (1993) provided information on the conservation status of the species in the southeastern United States from Virginia to Georgia, and Arndt (1977) studied the natural history of bog turtles in Delaware. Landry (1979) provided a bibliography of literature on the bog turtle

containing 158 references. Conservation status has been addressed by many authors, and a balanced summary was presented by Arndt (1978).

Figure 1. Current distribution of the bog turtle, *Clemmys muhlenbergii*.

In 1974 Lee prepared a status report on this species in the southeastern United States for a publication then being proposed by the Tall Timbers Research Station. The focus of his account was the dependence of bog turtles on sedge meadows, the narrow successional window in which populations prospered, and the fragile nature of this subclimax seral stage as it related to local hydrology and land alterations. Although the published version of the Tall Timbers symposium never materialized, much of the habitat information from that study is presented herein.

Systematics

The genus *Clemmys* is restricted to North America. It is the only member of the subfamily Emydinae (Ernst et al. 1994). *Clemmys* is comprised of four extant species, three which occur in the eastern United States and are aquatic or semi-aquatic to terrestrial, and one western species, *C. marmorata*, which is the most aquatic in the genus. Additional species of *Clemmys* are known as fossils dating from the Paleocene (Romer 1966), Eocene (Hay 1908), and Pliocene (Brattstrom and Sturn 1959).

Clemmys muhlenbergii is the smallest species of Emydidae, and one of the smallest of the world's turtles. The maximum verified shell length is 108 mm (Ryan 1981), and the everage length of adults is less than 100 mm. Since its original description by Schoepff (1801) as *Testudo muhlenbergii*, it has been placed in at least nine other genera by various authors. The first use of the combination *Clemmys muhlenbergii* was by Fitzinger in 1835. Dunn (1917) described bog turtles from the southern Appalachians as a distinct species, *Clemmys nuchalis*. While this taxon is not currently recognized, we are unaware of detailed systematic work evaluating differences in any of the disjunct populations. Minimally, there appear to be differences in the pigment patterns on the necks and heads of individuals from northern and southern populations (Figure 2), but the extent of this variation alone is insufficient to warrant separating these as distinct taxa (Ernst et al. 1994). Carl Ernst and Jeffrey Lovich do have some data indicating that these populations are different (C. Ernst, pers. comm.). Bern Tryon and Dennis Herman (pers. comm.) are collecting blood samples from bog turtles at various localities for use in genetic analysis. Amato et al. (1993), reporting on preliminary results of the DNA analysis of these collections, found that the ten samples they tested exhibited unusually low levels of mitochondrial DNA variability. In contrast, Parker and Whiteman (1993), using DNA finger printing, showed greater genetic diversity in fragmented populations of spotted turtles. Studies on other freshwater turtles have shown genetic divergence to be greatest when intervening habitat is terrestrial (Scribner et. al. 1986).

The relationship of *Clemmys muhlenbergii* to other species in the genus is problematic. Electrophoretic studies by Merkle (1975) indicated that it is most closely related to *C. guttata*. Because of the number of protein systems sharing bands with *C. marmorata*, he concluded that *C. muhlenbergii* was closer to a common ancestral form than the other extant species of *Clemmys*. This same conclusion had been reached by Hay (1908), based on comparison of living and fossil *Clemmys*. However, Lovich et al. (1991) examined plastral morphology and found that *C. muhlenbergii* shared fewer similarities than the other three species in the genus, and were surprised at what they considered the relative dissimilarity of *C. muhlenbergii* and *C. guttata*. This is in contrast to Merkle's data, and the fact that *C. muhlenbergii* and *C. guttata* are known to hybridize (Ernst 1983).

The type locality of *Clemmys muhlenbergii* was listed simply as "Pennsylvaniae" and later restricted to Lancaster County by Stejneger and Barbour (1917). The karyotype was described by Bickham (1975).

Descriptions of this turtle are available in numerous publications. The most recent and probably most readily available descriptions and illustrations are provided by Conant and Collins (1991), and Ernst et al. (1994). This species is quite distinct and problems posed by identification of adult individuals are minimal. Hatchlings and young juveniles have been confused with the young of other *Clemmys* species, but this was before illustrations of the young of all three eastern species were readily available.

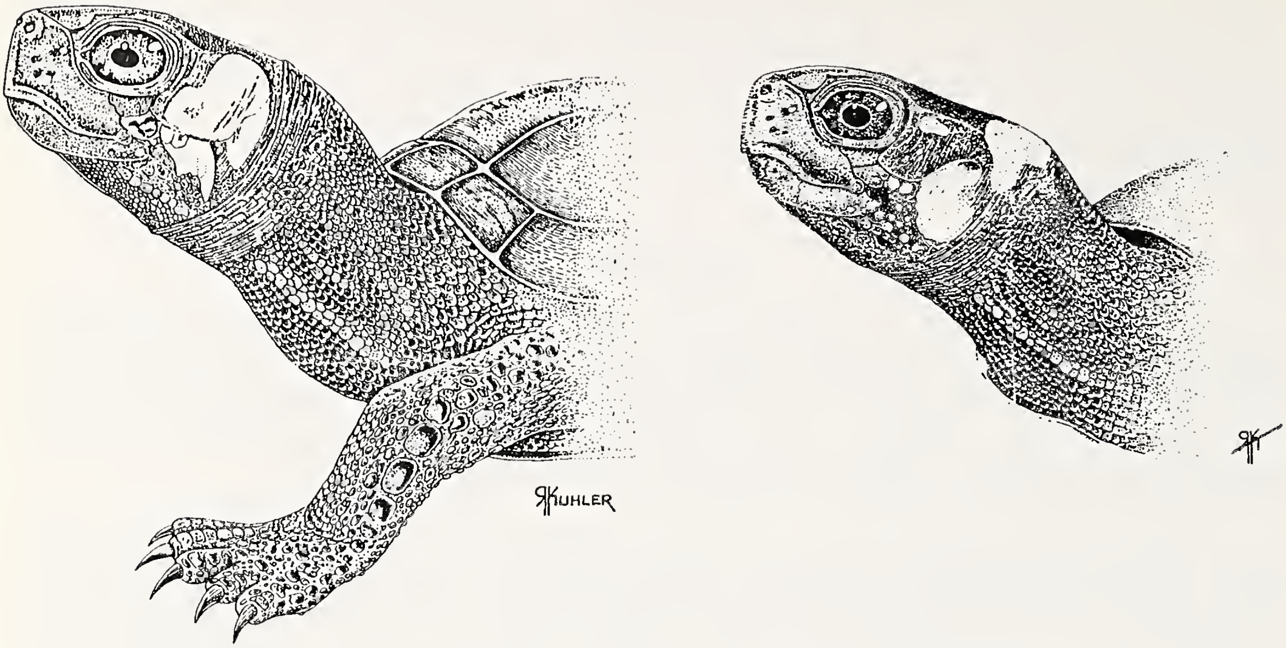

Figure 2. Pattern of orange pigment on head and neck of bog turtles from Baltimore County, Maryland (A), and the mountains of North Carolina (B).

Historical Overview of Bog Turtle Research in Maryland

While the first bog turtle from Maryland was reported by McCauley and Mansueti in 1943, Cope (1873) had reported it in the "northeastern portion of the State" during the previous century. Cope did not refer to any particular Maryland specimen or locality, and his statement may have been based on the proximity of that area to Lancaster County, Pennsylvania, where bog turtles were then well known.

The first Maryland specimen was collected on 8 August 1941 along Poplar Run near Grave Run Road, about one mile north of Grave Run Mills and two miles WSW of Rockdale in Baltimore County (Figure 3a). The circumstances under which it was found were atypical, which is unfortunate since the account was widely cited and believed typical of the biology and ecology of this then little known turtle. The animal was found embedded in hard clay beneath a board 15 or 20 feet from the stream (McCauley and Mansueti 1943, 1944). Robert McCauley (1945) discussed the turtle from Grave Run Mills in detail. That specimen now resides at the Natural History Society of Maryland (NHSM 450).

John Cooper (1947, 1949) reported additional specimens he and others obtained along the Susquehanna River floodplain in Cecil County, Maryland. The habitat was described as small, intermittent, vegetation-choked ponds. Cooper did not otherwise characterize the habitat but did provide a list of other reptiles and amphibians known from the immediate area.

Howard Campbell (1960) reported on a previously unknown colony he monitored in northern Baltimore County, one mile SW of Whitehall. In that same paper Campbell mentioned two other sites, one near Eko (=Eklo) in Baltimore County and one from Broad Creek in Harford County. The areas occupied were referred to as "swamps", but the descriptions of the habitat suggest that they were marshes bordered by wet meadows. Reed (1956) and Prince et al. (1957) had previously reported the species from the Broad Creek area.

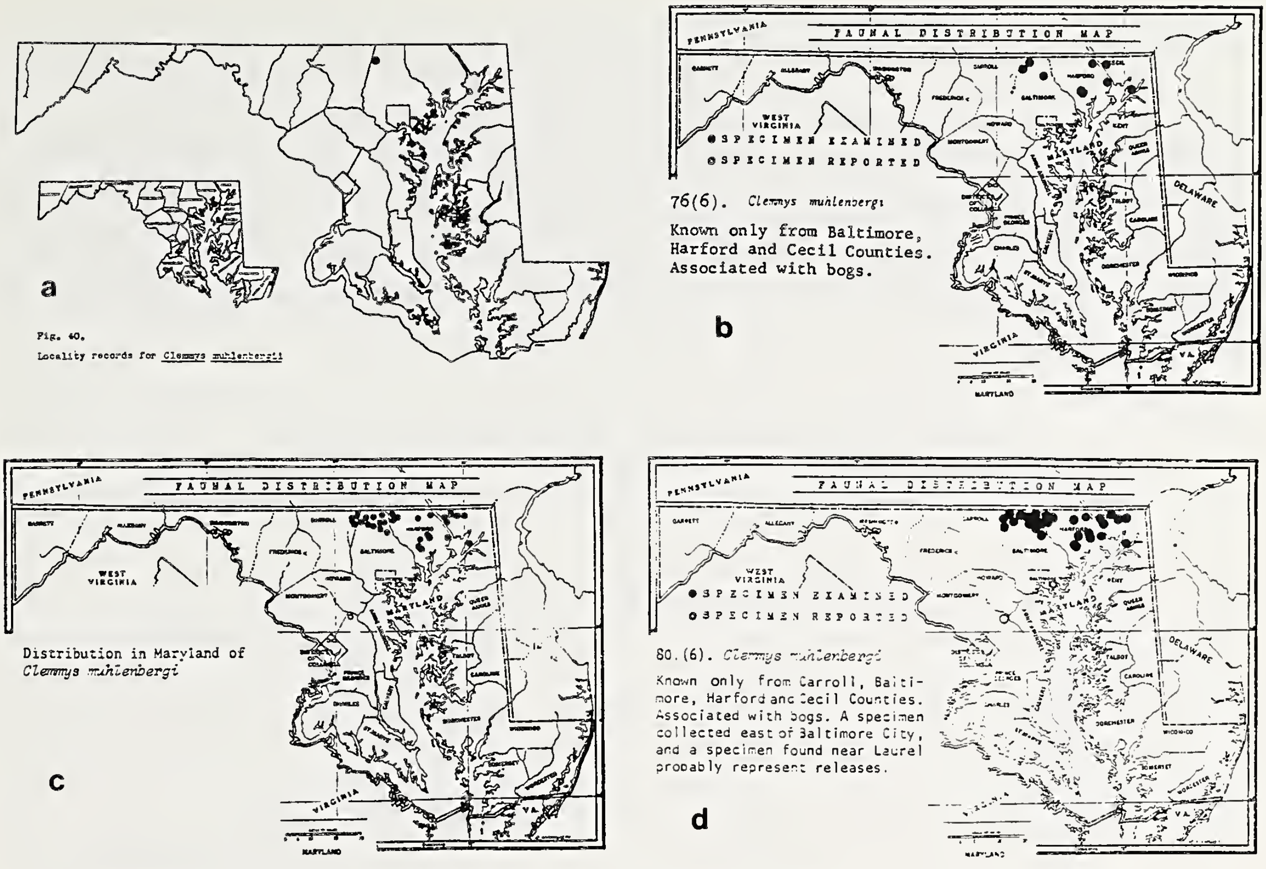

Figure 3. Previously published maps depicting known distribution of bog turtles in Maryland. A, McCauley (1945); B, Harris (1969); C, Cooper et al. (1973); D, Harris (1975). Maps reproduced with permission from the Natural History Society of Maryland.

By 1960, when John Cooper published his survey of the distribution of Maryland amphibians and reptiles, bog turtles were known from only the above mentioned sites in three counties. By 1969, when Herbert Harris updated and expanded the format of the state herpetological survey, the number of sites had risen to nine, in the same three counties (Figure 3b). By the time Harris revised his survey (1975) the total number of colonies had risen to 30, and the species was also known from northeastern Carroll County (Figure 3d). These early state surveys did much to promote herpetological record-keeping in Maryland, and resulted in a great increase in the number of known records for various species. Efforts by several local naturalists, specifically focusing on bog turtles, were responsible for the three-fold increase in the number of localities discovered between 1969 and 1975.

In the mid-1960's Nemuras (1966, 1967) reported additional sites for bog turtles he located in northeastern Maryland. These were important finds and provided the first hints that the earlier specimens from Maryland represented more than isolated, peripheral records. His 1967 study also gave valuable insight into the habitat requirements of this species. Previous published information was anecdotal, and much came from specimens found in marginal habitats.

In March of 1969 Lee headed up a committee of the Maryland Herpetological Society (Natural History Society of Maryland) established to survey for new bog turtle sites, and to evaluate those already known. In three months, three people working on weekends added 20 new sites to the list of known localities. The project was terminated because it was felt that the additional attention was encouraging collecting that

was draining local populations, and one member of a field party antagonized land owners to the extent that one site was deliberately filled-in for no other reason than the property owner did not want to deal with amateur herpetologists. In a subsequent letter to the president of the Maryland Herpetological Society, Lee remarked that the species was much more widespread in the Baltimore, Harford, and Cecil County area than previously suspected, and that the real issue appeared to be management of the early successional bog/meadow communities that appeared to be optimum habitat for *Clemmys muhlenbergii*. In the course of that survey the term "sedge meadow" was first used to describe good bog turtle habitat. The number of new colonies located is reflected in the distribution maps presented by Cooper et al. (1973) and Harris (1975) (Figures 3c and 3d). Table 1 shows how the number of known Maryland sites grew between 1873 and 1984.

Table 1. Total number of known bog turtle localities in Maryland

Year	Number of known sites	Source
1873	no specific record	Cope (1873)
1937	one unverified record	Brady (1973)
1944	1	McCauley and Mansueti (1944)
1945	1	McCauley (1945)
1949	2	Cooper (1949)
1960	5	Campbell (1960)
1969	9	Harris (1969)
1973	30	Cooper et al. (1973)
1975	30	Harris (1975)
1984	177	Taylor et al. (1984), Dawson (1948)

Because of the listing of the species as endangered by the State of Maryland in 1972 (Annotated Code of Maryland, Article 66C, Section 125) and the recommendations made by Cooper et al. (1973), the Maryland Department of Natural Resources initiated a study in 1976 to more accurately determine the distribution and abundance of the bog turtle in Maryland. The primary purpose of that study was to locate and catalogue sites, but it also sought information on habitat requirements (Dawson 1984). Six hundred and eighty-nine "potential" sites (identified by soil type) were examined in Carroll, Baltimore, Harford, and Cecil Counties, and 173 sites supporting bog turtles were located. Twenty-three of the 30 "historic" sites were also resurveyed at that time, but turtles were found at only four. Because of the unexpected number of new sites located, the species was removed from the state's protected species list by the Maryland Department of Natural Resources in 1982, despite evidence that a large percentage of the known historic sites no longer supported turtles.

Chase et al. (1989) studied habitat characteristics, population size and home range of Maryland bog turtles. They found considerable variation in population size at the 20 sites studied in detail, and attributed the variation to habitat characteristics and differences in carrying capacity. They found home ranges to be larger in adult males ($\bar{x}$ = 0.176 ha) than in adult females ($\bar{x}$ = 0.066 ha), and noted considerable overlap between areas occupied by individuals of both sexes. This important study was an essential step in understanding the ecology of bog turtles in the central portion of their range.

Charles Stine (unpublished) studied the seasonal movements of bog turtles at a site in northern Carroll County. With radio-telemetry he tracked four turtles for a two year period to document migration to and from hibernation sites, and daily activity patterns at different seasons. The turtles studied were active from late March through the first week in November. The period spent hibernating and the nature of the sites

selected were consistent with data presented by Ernst et. al. (1989). He also found that turtles were active throughout the day and did not estivate during the summer.

Between 1953 and 1956 Lee repeatedly attempted to capture an adult bog turtle living in a small pond at the edge of an open woodland well south of the other sites where this species was then known to occur in Maryland. That individual was clearly observed on numerous occasions and, although never captured, its identity is certain. The site was in Baltimore City in a large, then relatively undisturbed woodlot at the northwest corner of the intersection of Northern Parkway and Loch Raven Boulevard. Loch Raven Boulevard had recently been expanded and the construction corridor bisected the pond. Clumps of sedges at the upper end suggested that the site had been relatively open previously, and that the pond had been created by road construction. The locality was reported to Herbert Harris for his 1963 distribution survey, but Harris considered the animal to be a released captive. At that time the Loch Raven Boulevard/Joppa Road area (a few miles to the north) contained extensive areas of spring-fed sedge meadows and small meandering streams, but that habitat was not surveyed for bog turtles prior to its destruction.

In the latest version of his distribution survey of the amphibians and reptiles of Maryland, Harris (1975) showed two other records of bog turtles located southeast of their known local range. One of these, plotted as just east of Baltimore City (Harris 1975), was based on a specimen collected from "Hall Spring" in Herring Run Park by Glen Fullano and Dave Sieminski on 13 May 1973. That specimen now resides in the collection of the Natural History Society of Maryland (NHSM 1816). Hall Spring is a small resurgence generating about eight or nine gallons of water per minute (Otton and Hilleary 1985). It is located within a city park, adjacent to a major urban roadway. The spring itself has a concrete wall and floor, with discharge pipes and a drain. No habitat suitable for bog turtles is present today, but we have no record of the condition of this site when Fullano and Sieminski collected their turtle.

The second specimen was collected in a marsh along the north side of Maryland Route 198, east of Laurel in Prince George's County. William Grogan (pers. comm.), who lived in the area, recalls that the locality was a shallow wetland with tussock sedges, and it struck him as likely habitat for this species. When we visited the site in June 1992, it was an open cattail marsh with relatively deep standing water. At that time the only turtles in evidence were painted turtles (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*). The dramatic change in this site was apparently due to hydrologic changes resulting from the widening of Route 198, and there is no reason to believe that it was not acceptable habitat two decades previously. We were unable to locate this specimen among the series of bog turtles at the Natural History Society of Maryland.

Both of these records were mapped by Harris (1975) (see Figure 3d). However, their occurrence beyond the expected local range persuaded him that they had been released and did not represent remnants of natural populations. Looking back, the probability that two bog turtles would be released (remember that this was a time when few local naturalists had even seen this species), then recaptured by someone who knew what they were and brought them to the Natural History Society of Maryland, seems very small. We consider it more probable that these specimens came from colonies that were dying as a result of environmental changes generated by development. It seems likely to us that other now extirpated, disjunct populations of bog turtles in the greater Baltimore Metropolitan Area suffered the same fate.

Other interesting accounts of bog turtles in Maryland and adjacent Virginia are those reported by Brady from the Plummers Island-Stubblefield Falls area just west of Washington D.C. (Brady 1937, McCauley 1945, Manville 1968). These sightings were made between 1924 and 1955, and have generally been disregarded by regional herpetologists. Brady's 1924 record from Stubblefield Falls, Virginia was shown to be a young wood turtle by Barton (1960). While this certainly casts doubt on the Plummer's Island records, it does not prove them erroneous. We do not wish to suggest that the bog turtle actually occurred in the D.C. area in historic time. In fact, a zoogeographic analysis conducted by Lee and Dennis

Herman (1995) suggests that its occurrence in that area was unlikely. Our intent is simply to discuss these Montgomery County reports to make this record complete.

We should point out that most of the other reptiles and amphibians reported by Brady from the area are within the accepted modern distributional limits, and that he also recorded both of the other native species of *Clemmys*. The Stubblefield Falls report (Brady 1937) was not based on a specimen found by Brady, but the 1955 sightings were his personal observations. We checked the notes Brady made in the Plummers Island logbook maintained by the Washington Biologists' Field Club, and found nothing to clarify the identity of the turtles he observed. In his log book entry, he simply reported bog turtles on 9 March 1955 in the "lower pond on mainland. Temperature 67° at 5:45 pm." There is no indication that the 1955 specimens were captured or retained. Carl Ernst (pers. comm.) and his students have searched the area without locating this species, and found no typical habitat in the Plummer's Island vicinity. The "lower pond" is, in fact, a series of vernal pools. It is interesting, however, to note that a small seepage wetland does occur in a nearby forested ravine, adjacent to the C & O Canal towpath near Lock 11. Although that area is now heavily forested, Erwin (1981) noted that most of the area was cleared in the 1800's. At that time this wetland may have been a sedge meadow.

There is one other mention of bog turtles in this same general area. James Fowler (1945) prepared a list of the herpetofauna of the National Capital Parks in the Washington D.C. area when he served there as a ranger-naturalist. In it he included, without further comment, the occurrence of the bog turtle in the Chesapeake and Ohio Canal National Historic Park. However, Fowler (pers. comm.) informed us that inclusion of *C. muhlenbergii* in his list was based solely on the Brady records.

Based on information presented here, and records from adjacent states, we strongly recommend systematic surveys in eastern Cecil County, Kent and northeastern Queen Anne's County in Maryland. The occurrence of the species on the coastal plain of Delaware (Arndt 1977), and the presence of other relict, upland freshwater species on the Delmarva (Lee 1976) suggest that it may occur on the adjacent Atlantic Coastal Plain of Maryland. We also suspect that colonies might occur in Howard, eastern Frederick, and northern Montgomery Counties. We further suggest that populations may have occurred historically in Prince George's and northern Anne Arundel Counties. Records from Franklin Co., Pennsylvania (Ernst 1985) suggest that the bog turtle may also occur farther west in Maryland than is currently known. This is a species where relict and semi-relict distributional patterns represent the norm and, unfortunately, much of the Maryland piedmont was developed or converted to agriculture before systematic herpetological surveys were conducted.

Zoogeography

The fossil record for this species is scant and provides little insight into its past distribution. We are aware of only one published fossil record of *C. muhlenbergii*, from the Cumberland Bone Cave near Cumberland in Allegany County, Maryland (Holeman 1977). Although this is virtually the only record for this species within the Potomac River drainage, it is only slightly outside the species' known current range. The herpetofauna associated with this fossil includes mostly modern species which are present in the general area today, although the presence of the fox snake (*Elaphe vulpina*) suggests that at least some of the fauna is of mid-western origin. The mammalian fauna of this same deposit has been well-studied (Gidley and Gazin 1938, Nicholas 1954) and includes many mid-western species such as badgers (*Taxidea taxus*), coyotes (*Canis priscolatranus*), thirteen-lined ground squirrels (*Spermophilus tridencenlineatus),* and pocket gophers (*Thomomys potomacensis)* (Gidley 1971). It is equivalent to the Kansan fauna from about 600,000 years before present (ybp).

Smith (1957) presented evidence for a "prairie peninsula corridor" which allowed many prairie species of plants and animals to extend their distributions eastward into the area now occupied by middle latitude deciduous forest. Stuckey and Reese (1981) compiled a considerable amount of information on the prairie peninsula concept. Most of the information they presented, however, is from Ohio and other states west of the Appalachians. Today, there are many relict populations of prairie species in the central Appalachians and middle Atlantic states, and there are relict and highly disjunct populations of other prairie species in western New York and western Pennsylvania. Smith (1957) discussed the biogeography of the prairie peninsula in detail and showed how glacial influence could have affected the distribution of bog turtles and other species of reptiles and amphibians. We agree with Smith (1957) that the bog turtle may be of midwestern prairie origin. Glacial retreat opened up unoccupied habitats to the north, and glacial gouging created basins for bogs, including some which are extant today. We suggest that the gradual reforestation of glaciated areas fragmented the bog turtle's northernmost populations after the last glacial advance. The major portion of the bog turtle's current range is south of the glacial maximum.

We suggest that this species originally evolved in wet prairie habitats west of the Appalachians and expanded eastward during inter-glacial periods. During subsequent glacial periods eastern bog turtles were confined primarily to wet prairies of the lower Susquehanna basin, and in the Southern Appalachians, more or less where they occur today. During these glacial periods, most regions of North America were drier than they were during the interglacials, since vast quantities of freshwater were stored as ice (as thick as 10,000 feet) and snow. Thus, wet prairie regions south of the glacial advance became fragmented and were eventually lost as suitable habitat for bog turtles through drying, and those to the north were covered by ice. During the more recent interglacial periods, and at the end of the last glacial advance, the southern Appalachian population remained isolated, as it is today. The turtles in the Susquehanna refugium expanded northward into habitats in basins left by glacial scouring (many to later disappear because of natural succession). Others expanded north and east into adjacent river systems, primarily the Delaware and Hudson Rivers.

Based on evaluation of a fossil herpetofauna recovered from a cave in eastern Quebec and another from Highland County, Virginia, Fay (1984) concluded that in nonglacial Quaternary environments the local reptile and amphibian fauna of 30,000 years ago was nearly identical to that of present times. Climatic conditions may have been fairly similar to those now found in the mountains of southwestern Virginia, suggesting that a bog turtle refugium could have been present in the Southern Appalachians for a very long period.

The native Susquehanna fish fauna includes northern Mississippi basin species that used post-glacial outlets. Hocutt et al. (1986) list 12 fish taxa that are clearly in this category. By contrast, the Delaware River has a less rich fauna, and was not directly linked to Pleistocene glacial outlets. Thus, if bog turtles do represent part of a fauna of midwestern prairie origin, the northern population had direct access at least to the Susquehanna and Hudson Rivers, and, through subsequent lateral captures (or at least shared areas occupied by tributaries), access to adjacent systems in Maryland, Delaware, New Jersey, and New England. The current shared fauna suggests that prior to formation of the Chesapeake Bay (starting about 15,000 years ago) the Susquehanna River had as tributaries all piedmont streams and rivers west to at least the Patapsco River. There is also good evidence that the Susquehanna previously turned east and crossed the Delmarva in the vicinity of Salisbury (Lee 1976, Coleman et al. 1990, Kerhin et al. 1996). Thus, the Susquehanna may have been connected to the Delaware basin as well. Bog turtles using the Susquehanna and Delaware river flood plains as corridors for dispersal would have had access to a network of river systems that drained over 39,500 square miles, until about 15,000 years ago.

If one looks at the distribution of bog turtles in Maryland from an aquatic zoogeographical perspective, the documented range in the Chesapeake Bay drainage falls almost entirely in the eastern division of the piedmont. Nearly all sites are confined to the river systems between the Susquehanna

River on the east and the Patapsco River on the west. This corresponds to area "C" as defined by Lee et al. (1981) and, excluding the unlikely Plummer's Island reports mentioned above, includes almost all of the previous historical (non-fossil) records from the state. The only exception is an occurrence in the Monocacy River drainage of Carroll County.

This portion of Maryland's drainage system supports 56 native species of fishes (Lee et al. 1981) several of which are of midwestern origin (i.e., stoneroller, *Campostoma anomalum*; silver jaw minnow, *Ericymba buccata*; walleye, *Stizostedion vitreum*; and logperch, *Percina caprodes*). These are mostly disjunct populations of Mississippi basin species which invaded the Atlantic slope either through a headwater stream capture by the Susquehanna, or through Pleistocene glacial outlets. This aspect of distribution patterns has been reviewed on a regional basis by Jenkins et al. (1972) and locally by Lee (1976). Additionally, the hellbender (*Cryptobranchus alleganiensis*) and the map turtle (*Graptemys geographica*) are both Mississippi basin species with disjunct populations in the Susquehanna River (the map turtle also occurs in the Delaware River). Their recent isolation in this area is evidenced by a lack of detectable differences between lower Susquehanna and Mississippi basin populations. The 444 mile length of the Susquehanna River, a system with a drainage area of 27,500 square miles, would be a likely corridor of dispersal for bog turtles and other prairie elements that invaded the eastern United States. The headwaters of the Susquehanna River are in Otsego County, New York and, therefore, would provide a connection with the area of glacial scouring in the proximity of upstate New York's relict populations of bog turtles. It is clear that the Susquehanna basin is a key element in the current distribution of *Clemmys muhlenbergii*. Nearly all major colony sites are in this or neighboring basins, and over 70% of the known sites for the species occur there. The proximity of the Susquehanna to the Delaware River basin, and the Delaware basin to colony sites in New Jersey and New England is obvious. The semi-aquatic habits of the bog turtle and its small size would tend to limit dispersal, and it seems likely that its current distribution is influenced by proximity of available habitat and natural dispersal routes.

The one other area in Maryland where bog turtles are now known to occur is just west of Parrs Ridge in Carroll County. There, these turtles are known from a few sites along Big Pipe Creek, a tributary of the Monocacy River (Potomac River drainage). These localities, the only recent ones documented anywhere in the extensive Potomac River basin, undoubtedly represent an isolated invasion of this drainage from the adjacent Susquehanna or Gunpowder Rivers. Since bog turtles are limited to this small portion of the Potomac River basin, we suggest that this crossover occurred quite recently.

Distribution During Pre-Colonial Period

The bog turtle's characteristic open meadow habitat (see Ecological Distribution) would have been difficult to maintain once the prairie peninsula receded. We propose that in pre-colonial times bog turtle populations centered around successional communities tied to beaver ponds, and perhaps to open areas maintained by periodic burning by native Americans or natural fires. Burning by native Americans was a common practice and may have played an important role in the survival of bog turtles in some areas during the past 10,000 years. Because of the frequency with which we have found bog turtles in grazed areas we also suggest that, prior to the colonial period, the grazing activities of large herbivores like the American elk (*Cervus canadensis*) and the American bison (*Bison bison*) may also have been important in the maintenance of bog turtle habitat.

John Donelson, in his 1780 journal (Roe 1951), noted that in Pennsylvania "The open space around and near the sulphur or salt springs, instead of being an 'old field', as had been supposed by Mansker, at his visit here in 1769, was thus free from trees and underbrush by the innumerable herds of buffalo and deer and elk that came to these waters." Shoemaker (1915) reported many such buffalo clearings and cited place names such as Clearfield, Pennsylvania, as evidence that such circumstances were common.

Portions of the known historic range of these large, grazing mammals rather closely parallel the current range of the bog turtle. We know from Seton (1909) that in Snyder County, Pennsylvania large numbers of bison and a few elk were present until the mid-1700's. The last bison in Pennsylvania were killed between 1783 and 1800 (Garretson 1938). Historically, salt licks along the Susquehanna River were known to be heavily used by elk and currently the lower Susquehanna basin is one of the major areas of concentration for bog turtle colonies. Elk were once so numerous in this area that "leading to the licks the paths of these animals were as large as many of the great public roads of our country" (Rhoads 1903). The last elk were killed in Pennsylvania in 1877 (Shoemaker 1915).

In North Carolina, elk were known from the mountains and northwestern piedmont but were eliminated by hunting by the late 1700's. In this same state bison were still common between 1720 and 1750, but had totally disappeared by 1765. Like bog turtles, they were known only from the western portion of the state (Lee and Funderburg 1977). The distribution of elk in Maryland is not well documented (Mansueti 1950, Lee 1984), but there is good evidence that they ranged east at least to the eastern edge of the piedmont. We know that they did occur around the District of Columbia, and elk are known from archaeological sites as far east as Frederick, Montgomery and Prince George's Counties. From place names (Elkridge, Elk Neck, Elk River, etc.) in Cecil, Harford, and Howard County, we assume they occurred in these counties as well (see Mansueti 1950). In Maryland, bison were present throughout the mountains and piedmont into the historical period (Lee 1984). Thus, these large grazing animals could have been key species in the maintenance of open, early successional meadow communities in all areas of the bog turtle's range from central Pennsylvania southward.

If one considers the landscape from an earlier perspective, the local occurrence of open meadows maintained by grazing may have been more pronounced than it was during the pre-colonial period. In the late Pleistocene large grazers and browsers were an important component of the fauna of eastern North America. Research conducted by David Stedman (pers. comm.) on various fossil sites within the Susquehanna drainage provides a good overview of the paleo-history of that region. He documented the local presence of such prominent herbivores as the ground sloth *(Megalonyx jeffersonii)*, giant beaver (*Castoroides ohioensis*), mammoths (*Mammuthus columbi* and *M. primigenius*), mastodon (*Mammut americanum*), horses (*Equus complicatus* and *E. fraternus*), tapir *(Tapirus veroensis)*, and peccaries (*Mylohyus nasutus* and *Platygonus compressus)*. All died out or were hunted to extinction when the first humans expanded into eastern North America (about 11,000 ybp). The early hunters concentrated on the larger ($\geq$ 44 kg) species of mammals.

As an aside, it is interesting to note that we have observed bog turtles in or adjacent to cattle droppings, where they appeared to be foraging on insects associated with the droppings. While bog turtles are dietary generalists, this type of feeding activity could have been important when open habitats were maintained by native late Pleistocene to pre-colonial grazers. We have also found bog turtles in the depressions made by cattle walking around and through wet meadows.

The beaver, *Castor canadensis*, undoubtedly created much habitat for bog turtles, and it is clear that this rodent was a major component of the fauna in the pre-colonial period. For instance, populations of beaver in Maryland must have been phenomenal. Guthein (1949) provided some quantification of the numbers removed from the area of the Potomac River in the early 1600's. In 1632 a single merchant exported beaver skins at a total value of 40,000 gold crowns. Another trader had "gotten 1500 weight of beaver." At one point there were 110 Indians "loaded with 4,000 weight of beaver skins." Another excerpt tells of seven thousand Indians, each with forty beaver skins. Even allowing for exaggeration, Maryland beaver populations must have been quite healthy in the early 1600's.

By the end of the 1800's fur trapping had all but eliminated the beaver from the southeast, and it was uncommon everywhere east of the Mississippi River. Bonwill and Owens (1939), and Mansueti (1950)

document the extirpation and eventual return of beaver populations to Maryland. Evidence for edge use of beaver ponds by bog turtles in Maryland is mostly anecdotal. Robert Simmons told us that he found bog turtles in the upper ends of beaver ponds at the Conowingo site in Cecil County. His turtles were found by lifting the overhanging thatch of tussock sedges. This was in the same area mentioned by Cooper (1949), but it is not clear if the small intermittent ponds Cooper referred to were originally beaver ponds. While beaver ponds certainly provide at least marginal habitat under certain conditions, stream impoundment could also create sedge meadows upstream of the ponds that would be ideal for sustaining small bog turtle populations.

The habitat needs of beavers have been studied in northern forests where quaking aspen (*Populus tremuloides*) makes up an important component of their diet. Typically, a beaver colony will occupy a given site for a number of years but when all the food plants within a reasonable distance are eaten the beaver colony vacates the site. The untended dam eventually gives way and the former beaver pond becomes a meadow. Aspens again fill the meadow and once the seedlings mature beavers will reoccupy the site. While this sequence of beaver colonization and recolonization has not been worked out for the central Atlantic states, there is no reason to assume that the pattern was not similar. Thus, along any given post-Pleistocene stream course bog turtles would have had a spectrum of open meadows, early successional woodlands and beaver ponds. In such a system, dispersal and colonization of reopened sedge meadows by bog turtles is easy to visualize. The constantly changing habitat mosaic at any given site might even stimulate dispersal of bog turtles. Kiviat (1978) also felt that beavers were instrumental in maintaining and creating bog turtle habitat.

Ecological Distribution

Throughout their range bog turtles occupy a variety of open wetland habitats. Most literature focuses on sphagnum-bog communities, resulting in the species' current common name. Netting (1927) noted that records from the northern edge of the species' range are from sphagnum-bogs, and considered tamarack-bogs their original habitat. He felt that their occurrence in clear streams further southward could be explained by the fact that boreal plant communities disappeared as post-glacial plant communities closed in upon such areas. At the time of Netting's study the habitat of bog turtles in the southeast had not been characterized and his assumption about habitat in the south was incorrect. Other early authors had described bog turtle habitat in terms which would not indicate bogs in the traditional sense, i.e. meadow ditches (Abbott 1882) and meadow streams (Street 1914).

Since bog turtles occur in a variety of open wetlands lacking a canopy layer, and over a relatively broad latitudinal span (34°N to 44°N), it is difficult to explain their fragmented geographic distribution based simply on habitat availability. Their spotty micro-distribution can be explained by local habitat availability, succession, limited dispersal ability, and current and past land use practices. In Figure 4 we illustrate the narrow geographic and geological availability of land area for bog turtle habitat.

Variation in terminology used to describe sites occupied by bog turtles, as well as the animal's common name, has caused confusion in characterizing typical habitat. Researchers from different areas and time periods have understandably been inconsistent in their use of terminology. Characterizations of habitat for this species are a mixture of geological terminology (fens, bogs, river floodplains, ponds), habitat descriptions (Appalachian bogs, marshes, swamps, beaver ponds), plant community characterizations (open canopy, grassy meadows) and combinations of these terms (tamarack-bogs). We feel that it is important to define both the physical characteristics and the plant community that a site supports when it is inhabited by these turtles.

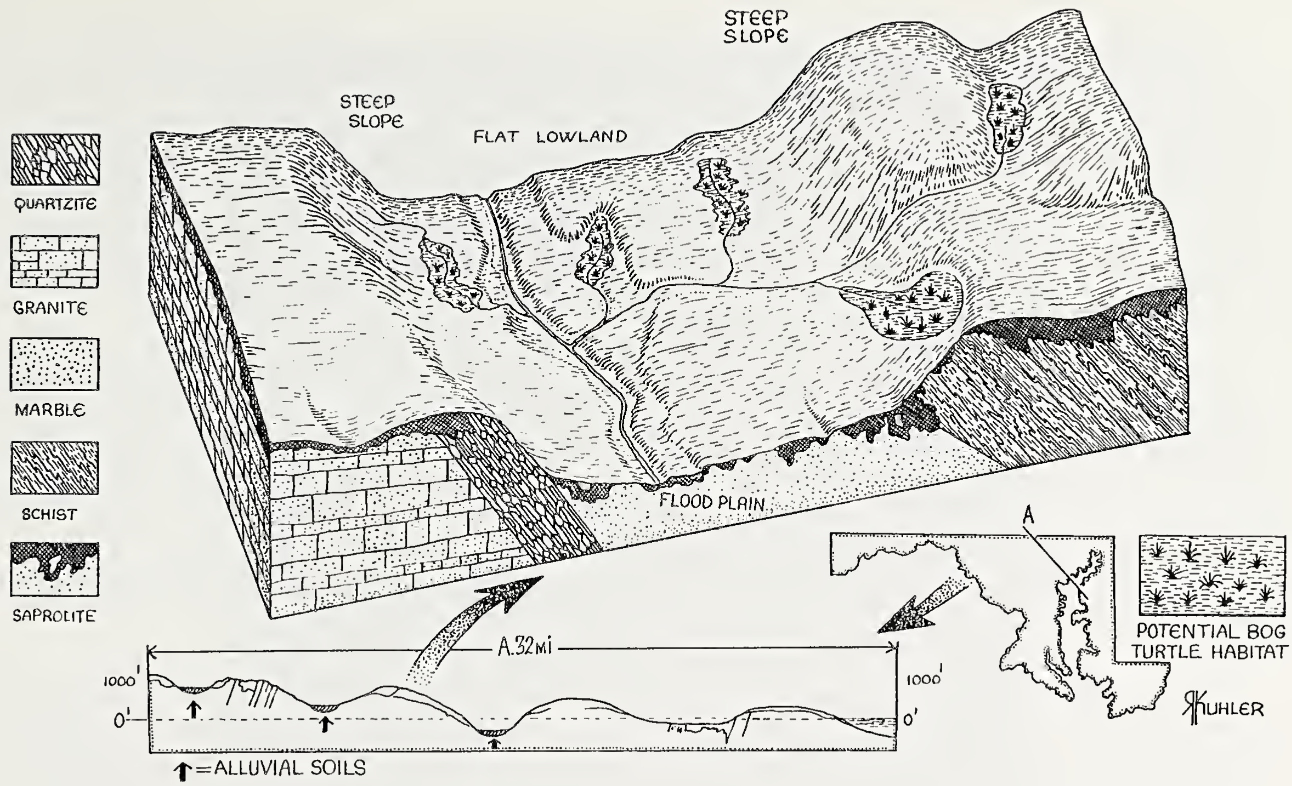

Figure 4. Generalized 32 mile NE-SW cross section through the Maryland piedmont (Baltimore and Carroll Counties) showing geologic and topographic units, and a profile of landforms (modified from Cleaves et al. 1974, and Brush 1975). Note limited areas of alluvial soil and the patchy occurrence of potential bog turtle habitat.

Bogs are typically composed of mats of vegetation which grow over ponds, small lakes and other natural depressions. The aquatic system is fed primarily and directly by rain. The *Sphagnum* and rooted vegetation of the shore grows out into the water, gradually advancing while slowly decomposing plant material fills the depression. Younger bogs often have open water in the center, while mature bogs become filled with encroaching shrubs and eventually shift completely to a terrestrial community. The amount of time required for this process varies, depending on the original depth of the basin (in the north many deep basins are the result of glacial scouring), drainage volume, frequency of fire, and annual temperature. *Sphagnum* is a major bog building plant. It decomposes slowly, retains a large volume of water even in advanced stages of decomposition, and has high acidity.

Shallow water communities with emergent vegetation are best referred to as marshes, and when the emergent vegetation is dominantly woody shrubs and trees, the communities are properly called swamps. Unlike bogs and sedge meadows, neither marshes or swamps provide optimal habitat for bog turtles.

Tryon and Herman (1990) consider fens to be spring fed habitats, and describe bogs as areas where water accumulation is from rain and run-off. Fens are traditionally flooded clay or peat areas (e.g., the Fenland District of eastern England). In the southeast (Virginia to Georgia) fens occur at high elevations, have a high pH, and have floristic affinities with calcareous fens of midwestern and northeastern North America (Weakley 1991). At this time bog turtles are documented from only one true fen in the Southern Appalachians, indicating that fens generally do not provide habitat suitable for bog turtles. An overview of southeastern mountain bogs and fens is provided by Richardson and Gibbons (1993). According to the U.S. Fish and Wildlife Service (1997), a significant number of newly discovered bog turtle sites in Sussex County, New Jersey occupy calcareous fen habitats.

A recent publication discussing management of forested wetlands (Welsch et al. 1995) illustrates the degree of confusion that currently exists over the habitat requirements of these turtles, even among scientists. It recommends "Within calcareous fens where chalky, crumbly deposits are evident in surface pools, preserve and encourage scrub and/or shrub habitats as important overwintering habitat for rare bog turtles." While mention of bog turtle habitat in a publication for wetlands ecologists is commendable, since very few fens actually support bog turtles, persons venturing into the field with this search image are likely to overlook most bog turtle habitat. More importantly, in most areas woody shrubs should be discouraged (see below).

Clemmys muhlenbergii was named by Ioannis Schoepff in 1801 for its discoverer, the Reverend Gotthilf Henry Ernestus Muhlenberg (1753-1815). Muhlenberg was a well known botanist responsible for the discovery and description of numerous plants, including many rushes and sedges. We suspect that Muhlenberg's attention to rushes and sedges led him to the habitat where this secretive turtle was discovered. It is likely that the type specimen came from a sedge meadow community. Beck (1928) noted that Muhlenberg studied rare wetland plants at a swamp in eastern Providence Township, Lancaster County, Pennsylvania, where bog turtles have been found, and speculated that the type may have come from that site.

Bog turtles inhabit true mid-to-late stage bogs in some portions of their range. They are normally not found in swamps or marshes. In Maryland they typically inhabit wet meadows formed by subclimax communities of grasses and sedges (Figure 5). These sites are usually located in level and low-gradient (3-8% slopes) spring fed areas that have modest amounts of permanent running water. Characteristically, they do not have standing water of significant depth. High gradient areas do not support bog turtles, possibly because high runoff velocity prevents accumulation of the soils necessary for sedge meadow development. Most stable sites are on flood plain terraces well above areas subject to regular flooding.

Tussock sedges, *Carex stricta*, are important to these turtles in Maryland. Bog turtles hide under the matted vegetation of the tussocks and use runways among them, and the tussocks are important egg laying and incubation sites. The matted dead vegetation of tussock and other sedges, rushes and grasses also forms a thick protective mat which may discourage predators. The mats of vegetation may be particularly important in the spring when they provide shelter prior to the appearance of new growth meadow vegetation. We have frequently noted the droppings of raccoons and foxes on top of these mats, demonstrating that these communities are regularly patrolled by predators. Campbell (1960), in discussing a site that apparently lacked tussock sedges, felt that raccoons were primary predators of bog turtles. The matted tussocks also appear to limit the germination of woody vegetation, and ice and snow mats the vegetation into a thick thatch that may inhibit invasion of other plant species.

Additionally, tussock sedges provide thermal protection and maintain high relative humidity. Zovickian (1971) noted that high relative humidity may be important for successful growth of hatchling bog turtles. Measurements of temperature and humidity taken beneath and adjacent to sedge mats at a Maryland bog turtle locality on 19 July 1992, between 10:00 and 11:00 AM, showed extreme differences of 10.3° C and 29.6% relatively humidity, with the runways under the tussocks being cooler and more humid than measurements made above the tussocks.

Platania and Sanders (1977) characterized the habitat of the bog turtle in the southern portion of its range. They noted that the species is found in sedge communities on silt loam soils (Baile, Codorus, Glenville, Hatboro, and similar soils). Herman (1991) noted that in the Blue Ridge between Virginia and Georgia, bog turtles prefer spring-fed wetlands that contain highly organic mucky soils (Codorus, Hatboro, Toxaway and other alluvial silt loams). The Maryland Department of Natural Resources has used U.S. Department of Agriculture soils maps to identify potential bog turtle habitat for survey purposes (Pitts 1978).

Figure 5. Typical sedge meadow habitat for bog turtles in Carroll County, Maryland. Note spring-fed flow of shallow water meandering between clumps of sedges. Woody vegetation is encroaching from the upper right.

Chase et al. (1989) characterized the Maryland habitat of bog turtles using 36 habitat variables to relate indices of population density to habitat characteristics. They found that the greater the index of population density, the more likely the colony site was to be located in a circular basin with spring-fed pockets of shallow water, a bottom substrate of soft mud and rock with interspersed wet and dry pockets, and dominant vegetation of low grasses and sedges. Sixty-one percent of the turtles they found were not in the water, but most were less than 20 cm from water. Seventy-eight percent of their captures were next to low grasses and sedges. We agree with their habitat assessment, and add that meadows should have sufficient elevation not to be flooded when stream levels rise and, while the shrub layer should not be dense, some scattered shrubs are desirable since adult turtles frequently hibernate among woody root systems and may also use these root masses as a refuge during other seasons.

In the early summer of 1974 Lee and Elmer Worthley set up three transects in a sedge meadow along a floodplain near Bel Air, Harford County, Maryland. The 1.2 ha site was chosen because it had a small colony of bog turtles (ca 30 adults) and was obviously undergoing fairly rapid succession. Permanent standing water had caused the site to be invaded by common cattail (*Typha latifolia*). The upper meadow section of the floodplain was being invaded by smooth alder (*Alnus serrulata*), green ash (*Fraxinus pennsylvanica*), and blackberry (*Rubus* spp.). The core of the habitat (about one acre) was still open and dominated by sedges, rushes and grasses. When the locality was revisited in July 1992, the cattail marsh had expanded and filled much of the site. The higher areas were on damp soils dominated by reed canary grass (*Phalaris arundinacea*), green ash, alder, buttonbush (*Cephalanthus occidentalis*), and halberd-leaved tearthumb (*Polygonum arifolium*). Despite the near total replacement of the original community, some remnant species of the original meadow, wool-grass sedge (*Scirpus cyperinus*) and skunk cabbage (*Symplocarpus foetidus*), were still present in modest numbers. At that time, no bog turtles could be found, even though turtles could always be located with reasonable effort in the 1970's. We cite the history of this locality because it documents the gradual succession of a habitat that had declined steadily since it was discovered in 1969. Despite the lack of change in land use at or near the site, we saw considerable change between 1969 and 1974, and a nearly complete shift in the plant community from wet meadow to cattail marsh between 1974 and 1992. These observations show that smaller sedge meadow sites can all but disappear in less than 20 years.

Large areas of one of our study sites in northern Carroll County, and several other Maryland sites examined by us, exhibited dense accumulations of ferrihydrate precipitated by 'iron bacteria'. These bacteria occur where iron-bearing groundwater discharges at the surface. Several genera of these microorganisms (*Sphaerotilus*, *Siderocystis*, *Leptothrix*, *Siderocapsa* and *Gallinella*) precipitate red flocculants of ferric iron that cover the substrate (Robbins et. al. 1992, Robbins and Norden 1994). Characteristically associated with them is *Leptothrix discophora*, which forms an oil-like film on the surface of the water. These precipitates are typical of groundwater-fed habitats in this area and have been observed at many of the bog turtle sites that we have visited. In fact, disturbance of these flocs and surface films can be a useful indication of recent bog turtle activity. On several occasions we were able to locate turtles by tracing their "trail" through the surface film to places where they had burrowed into the substrate. It is interesting that one of the earliest descriptions of a Maryland bog turtle site (Campbell 1960) described the water as being covered by a "red scum" and having an occasional "light oil slick."

The following is a listing of plants identified at one northern Carroll County site, with dominant species marked by an asterisk (*). Mosses: *Sphagnum** (at least five species are common in Maryland sedge meadows). Ferns: New York fern (*Thelypteris noveboracensis*), marsh fern (*Thelypteris palustris*), cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis**), hay-scented fern (*Dennstaedtia punctilobula*). Grasses and Sedges: lurid sedge (*Carex lurida*), tussock sedge (*C. stricta**), other sedges (*Carex* spp*), spikerushes (*Eleocharis* spp.), straw-colored sedge (*Cyperus strigosus*), rice cut-grass (*Leersia oryzoides**), fowl manna grass (*Glyceria striata*), velvet grass (*Holcus lanatus*), tickle grass (*Agrostis hyemalis*), and rushes* (*Juncus effusis*, *J. acuminatus*, *J. marginatus*). Other Herbs: skunk cabbage (*Symplocarpus foetidus**), many-flowered agrimony (*Agrimonia parviflora*), sweet white violet (*Viola blanda*), blue marsh violet (*V. cucullata*), small bedstraw (*Galium trifidum*), arrowhead (*Sagittaria latifolia*), jewel-weed (*Impatiens pallida**), joe-pye-weed (*Eupatoridelphus fistulosus*), New York iron weed (*Vernonia noveboracensis*), narrow-leaved mountain mint (*Pycnanthemum flexuosum*), boneset (*Eupatorium perfoliatum*), halberd-leaved tearthumb (*Polygonum arifolium*), purple-stemmed medaster (*Aster puniceus*), rough goldenrod (*Solidago patula*), swamp milkweed (*Asclepias incarnata*), nodding ladies'-tresses (*Spiranthes cernua*), skullcap (*Scutellaria* sp.), water horehound (*Lycopus americanus*), purple dead-nettle (*Lamium purpureum*), deer-tongue (*Dichanthelium clandestinum*), bugleweed (*Lycopus virginicus*), and square-stemmed monkey-flower (*Mimulus ringens*). Woody Shrubs, Vines, and Saplings: Japanese honeysuckle (*Lonicera japonica*), smooth alder (*Alnus serrulata**), American meadow-sweet (*Spirea latifolia*), steeple-bush (*Spiraea tomentosa*), red maple (*Acer rubrum*), black willow (*Salix nigra*),

northern arrow wood *(Viburnum recognitum)*, swamp rose (*Rosa palustris**), multiflora rose (*Rosa multiflora**), and maleberry (*Lyonia legustrina*). Prior to this survey *Galium trifidum* was believed extirpated from the state.

At the same site Stine (unpublished data) found that in the winter the middle and upper portion of the sedge meadow experienced freezing and thawing of the surface layer, causing uplifting of the soil. Spring runs could be heard flowing under the uplifted areas. Chase et al. (1989) in their habitat characterization of turtle colony sites noted that the most densely occupied areas exhibited interspersed wet and dry pockets. We feel that this freezing and uplifting of the surface layer is important in the annual maintenance of wet and dry pockets, and causes adult bog turtles to migrate to specific wintering sites where the substrate is more stable. The young of the year certainly do not undertake these migrations, and this may give them several weeks in the fall and early spring to forage in areas free of adults. In captivity adults occasionally prey on young (Arndt 1972) and there is no reason to assume that this does not occur in the wild. As far as surface upheavals exposing hibernating young to freezing temperatures, we expect that this is not a problem. Studies on young painted and box turtles (*Terrapene carolina*) show that they can survive freezing. How these very young turtles survive freezing temperatures is fairly well known (Pack and Packard 1995, Storey et al. 1988), and we suspect that young bog turtles also adjust physiologically to low temperatures.

Compared to other aquatic temperate species, a fair amount of information is available on the hibernation of bog turtles. Arndt (1977) reported that bog turtles in northern Delaware apparently hibernated for six months (mid-autumn to early spring) and Ernst (1977) observed no active turtles after October. Chase et al. (1989) found that the eight turtles they followed moved in and out of winter retreats from November to March. The turtles followed by Stine (unpublished data) moved in and out of hibernation in November and early March but always remained in close proximity to hibernation sites. During late December, January and February, they were essentially inactive and were found in the same position on each visit. Some inhabited communal winter dens that were used for more than one season. In New Jersey Holub and Bloomer (1977) found that bog turtles entered winter retreats in late October and emerged in early to mid-May. Ernst et al. (1989) studied over-wintering of *C. muhlenbergii* in Pennsylvania and New Jersey, and found the turtles to use a variety of sites.

A wide variety of other amphibians and reptiles occur in sedge meadows with bog turtles. Species found by us using a bog turtle site in northeastern Carroll County include dusky salamanders (*Desmognathus fuscus*), four-toed salamanders (*Hemidactylium scutatum*), long-tailed salamanders (*Eurycea longicauda*), American toads (*Bufo americanus*), pickerel frogs (*Rana palustris*), milk snakes *(Lampropeltis triangulum*), queen snakes (*Regina septemvittata*), ribbon snakes (*Thamnophis sauritus*), snapping turtles *(Chelydra serpentina*), and spotted turtles (*Clemmys guttata)*. Spotted turtles do not regularly occur syntopically with bog turtles, and we have a clear impression that these two small *Clemmys* prefer different micro-habitats.

In the southeast the bog turtle's distribution may be correlated with the distribution of two native mammals, the star-nosed mole (*Condylura cristata*) and the meadow vole (*Microtus pennsylvanicus)*. The mole constructs subterranean runways which are often water filled, and the vole makes surface runs just beneath the vegetation. Bog turtles make regular use of, and enlarge, both types of runs and are seldom encountered on the surface except when basking. Various aspects of the ecological and geographical distribution of the bog turtle in the southeast are closely mirrored by the star-nosed mole (Lee 1987) and meadow vole (Hall 1981). This turtle's regular use of vole runs was discussed by Lee (1970). The width of adult bog turtle shells (65-72 mm), compared to the normal width of *Condylura* (about 55 mm) and *Microtus* (about 60 mm) runs, seems large, but the runs are ideal for young turtles and are quickly widened by larger individuals. The frequency with which we have found bog turtles in these runs demonstrates a clear association.

Bog turtles are opportunistic feeders, capturing a wide variety of terrestrial and aquatic organisms, primarily invertebrates. They also consume vegetation and berries, and occasionally take carrion. These turtles are able to fed on land or in and under water.

Population Density and Home Range

In suitable habitats bog turtles exist in high densities. Chase et al. (1989) estimated a high of 213 turtles per hectare based on a mark-recapture study. Holub and Bloomer (1977) reported average densities of up to 40 adults per acre (0.4 ha). At the site studied by Stine (unpublished data) the density of bog turtles was estimated to be 100 turtles in a 1.6 ha area. Stine also found that the summer home range of both sexes overlapped, and it was not uncommon to find several adults within a one meter area. Chase et al. (1989) found that bog turtle home ranges were less that 0.2 ha, and were slightly larger for males ($\bar{x}$= 0.176 ha) than females (0.066 ha). This is quite a bit smaller than known home ranges for other eastern *Clemmys*. Spotted turtles have home ranges of approximately 0.5 ha (Netting 1936). Wood turtles have larger home ranges, estimated in various studies to be from 0.8 to 4.9 ha (Harding and Bloomer 1979), or from an average of 3.3 ha for females to 4.99 ha for males (Kaufmann 1995), to as much as 24.3 ha (Quinn and Tate 1991).

Although aggression between bog turtles has been noted, particularly toward smaller conspecifics (Holub and Bloomer 1977), they seem less aggressive that spotted turtles or wood turtles. In spring, male spotted turtles are quite aggressive and exhibit combat by biting the front legs of opponents. We have observed bouts of combat lasting ten minutes or more, and the scales on the front legs of many adult males show significant scarring. Combat in male wood turtles has been reported by Harding (1990), and both sexes are solitary except during mating. The high population density exhibited by colonies of bog turtles is unusual for *Clemmys*, and is possible because of the animal's small size, relatively passive nature, and, presumably, the high productivity of its wet meadow habitat.

Use of Marginal Habitats

There is some evidence of bog turtle populations surviving in marginal habitats. In South Carolina the one known locality is an area of small interconnected pools separated by former beaver dams (Herman and Putnam 1982). The pools are surrounded by deep mud and large stands of rushes. The Georgia localities are in areas with dense brush and a canopy, along a small mountain stream in a dense forest with little ground level vegetation. This apparently represents a remnant habitat largely succeeded to mature forest. Tryon and Herman (1990) noted a lack of potential nesting and incubation sites at this location and found that the few individuals observed were old adults. While such populations are of questionable viability, it is significant that adult turtles can survive in such habitats. Bog turtles are long lived, with a recorded life of 35+ years (Herman 1990). Because of this, animals holding on in suboptimal situations would serve as "seed stock" for colonies which could resurge after fire, impoundment of water courses and opening of the canopy layer by beavers, or a variety of anthropogenic changes might result in a return to suitable habitat.

Local land use from the colonial period until the present would appear to have maintained, if not enhanced, bog turtle habitat. Clearing for agriculture or grazing of domestic stock suppressed succession of open meadows, as grazing by bison and elk did previously. By the mid-1900's, mowing and regular canopy removal for utility line rights-of-way and other permanent disturbance may have created more "permanent" habitat than had existed in the pre-colonial period. Several existing Maryland bog turtle sites, for example, are in mowed areas under power lines.

The site monitored by Stine (unpublished data) is a 1.6 ha area that, until the late 1970's, had been used as pasture for dairy farming, and had been grazed for nearly a century. When the local dairy industry became less profitable the cows were removed but the land owner continued to periodically burn the sedge meadow to keep it open. In the late 1980's new county ordinances discouraged burning and, since that time, while the site still supports an active bog turtle colony, it has undergone uninterrupted succession and is now rapidly being invaded by woody shrubs and saplings.

Where suitable patches of habitat occur in close proximity, within a common drainage, it is likely that bog turtles wander from patch to patch. However, the significance of this exchange of turtles on population structure and the genetics of the colony is unknown. Such wandering turtles probably once played a significant role in repopulating newly opened sites. However, now that so many sites have been destroyed, and many intervening stretches of streamside habitat have been cleared or developed, the movement of bog turtles to new sites is being made more difficult, if not precluded. Bog turtles are less likely than spotted or wood turtles to wander outside defined colony areas, and turtles such as painted and snapping turtles, which are more aquatic, are much more frequently found on roads and in areas well removed from suitable habitat than are bog turtles. Research examining the significance of inbreeding and reduced genetic diversity of isolated groups of bog turtle would be very useful.

Conservation and Management

Status/Terminology

Some recent population surveys have indicated an increase in the number of known bog turtle "colonies," suggesting that the bog turtle's apparent rarity reflects inadequate survey rather than a scarcity of turtles. This results from adding the number of known historic sites to those recently discovered. The totals are impressive only to people not directly involved in field work with the species, and we fear that most published tallies do not reflect reality. First and foremost, sites are being lost at a rapid pace as a result of changing land use and natural succession. The actual number of currently inhabited sites is seldom known for any region. This is due to the widely scattered nature of the sites, the fact that most are on private property and seldom monitored, and that the few people with access to site locations are often unable to spend the time necessary to conduct follow-up field studies.

Another aspect of this problem is how colonies have been defined. Many of the sites listed and totaled for various regions and states (see Table 2) are places where only a few turtles have been found, often only one animal. Records, sites, and populations are terms used interchangeably by persons writing reports and attempting to summarize known records. None of these necessarily represent viable colonies. "Occupied colonies" may represent localities with only one or two turtles. Only in rare cases (i.e., Herman and Tryon 1993) has current reproductive success been factored into efforts to define what constitutes a viable colony. Various researchers have used different levels of verification to classify extant, viable, and extirpated sites. We would be surprised if 150 of the sites totaled for the entire range (Table 2) of the species are viable. Tryon and Herman (1990) believed that only 52 to 54% of the total recorded localities in the southern Appalachians have potential for current bog turtle populations.

Another problem with using individual "colony" totals to express population status, is that an unknown but significant number of sites are in such close proximity that counting them as separate colonies is misleading. Most surveys in Maryland and elsewhere during the late 1970's and early 1980's simply documented locations of occurrence with little regard for relevant factors which would be useful in predicting population size or viability. Lest this seem like harsh criticism of colleagues who conducted these surveys, we should acknowledge that their work was timely and important to our current understanding of this species and its biological requirements.

The problem, as we see it, is that administrative decisions regarding the bog turtle have frequently been based on compiled regional reports of field studies conducted over the last two decades. A recent report by Bourg (1992) demonstrated all of the pitfalls listed above. Terms like colony and population were used repeatedly with little indication of the actual number of turtles or the viability of isolated "colonies." Nor was there any indication of the degree or significance of genetic exchange between those sites that were in close proximity.

To provide consistency of terminology, we suggest the following. A "record" is a verified report of the occurrence of one or more turtles. A "site" is a place. A "colony" represents a site or a number of interconnected sites with an interacting group of breeding turtles. A "viable colony" is one that should be able to maintain itself and occurs in a place where the plant community, land ownership and management is reasonably stable (i.e., 30-50+ adults, two or more ha, indication of recruitment of young animals into colony, etc.). A "population" is the total number of turtles living in sites within a defined and separate geographic area (i.e. Southern Appalachian population, western Pennsylvania population).

Documented Decline

Even with the most optimistic of population estimates, there are not many bog turtles. This in itself is not necessarily a serious concern. There are many species that, because of various biological factors, are naturally uncommon. The problem in this instance is the small area of total habitat available, the vulnerability of this habitat, and this turtle's documented decline. There are many species currently listed as federally Endangered which clearly have larger populations, higher annual reproductive rates, larger geographic ranges, and wider spectra of ecological tolerance than the bog turtle.

Reviewing the situation in Maryland, Taylor's 177 (Taylor et al. 1984) sites were clusters of interconnected localities, and the number of colonies (both active and historic) is much smaller. A number of sites/colonies have been lost since the mid-1970's (at least 43% decline in historic sites surveyed) and there are no important sites on protected public land. None of the sites on public land have potential to support substantial colonies in the future, even if they were to receive effective management. Furthermore, when Lee outlined a population monitoring/site management study he wanted to initiate and asked wildlife managers in Maryland if they knew of a sizable colony (ca 50+ turtles) of bog turtles that they thought would be stable enough for a 10-year population study, they knew of none. Only several known sites were of that magnitude, and all of those were on private property owned by elderly landowners, and their future was uncertain. To us, this was alarming information.

Of the 12 states in which the bog turtle is now known to occur, four (Massachusetts, Tennessee, South Carolina and Georgia) have only peripheral records or turtles known from small, isolated sites. In most of these states the turtle is known from a single county, and if one excludes historic records and single occurrences of animals found on roads etc., each of these states has only one or two known sites. However, of these four states, Massachusetts and Tennessee are known to still have viable colonies. Of the remaining states (Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia and North Carolina), the turtle occurs only in a small area of each, except for New Jersey. A typical site is 2 ha or less. If we assume that an average site occupies 1.5 ha and that there are 227 known extant sites (Table 2), the total area occupied by these turtles represents about 341 ha (Tryon and Herman [1993] estimated 130 ha for the entire southeast). Herman and Tryon (1993) estimated that perhaps only 52% to 54% of the total recorded localities in the southeast (Virginia to Georgia) had potential for bog turtles, but Tryon (pers. comm.) now thinks the 54% estimate is probably much too high for viable long-term populations in the south, and feels that 20% is more realistic. Herman and Tryon (1993) additionally document a 46% net reduction of habitat in the southeast in just the last 15-20 years. Accordingly, the combined total area now occupied by the species is probably less than half the size it was only two decades ago.

Chase et al. (1989) calculated an average of 44.2 turtles per site in Maryland. Their sites, compared to those in the Southern Appalachians, seem to have larger populations so this figure is too high for use throughout the animal's range. While some large sites do exist in Floyd Co., Virginia, and perhaps in Alleghany Co., North Carolina and Sussex Co., New Jersey, the average colony in these states is much smaller than 44 turtles. However, if this estimate is used in combination with the approximation of 227 occupied sites (Table 2)[1], it gives a total estimate of only 9,988 individuals. If we add to this the number in captivity in zoos and other responsible institutions (84 individuals, International Species Information System 1992), the estimated total number of existing bog turtles is still less than 11,000.

In terms of density of turtles per hectare, the studies cited by Bourg (Eglis 1967, Barton 1957) represented large healthy colonies. Chase et al. (1989) gave a figure of 7 to 213 turtles per hectare. The average of their figures shows a mean of 58.7 turtles per hectare. Again, we think this figure is high for areas outside Maryland, and probably high for Maryland, where our field experience indicates typically lower densities. Using a figure of 357 occupied hectares of habitat, and the density figures given by Chase et al. (1989), we arrive at an estimate of less than 21,000 turtles for the species' total range. Thus, we have very crude population estimates of from 10 thousand to 21 thousand individuals in the global population. We consider these figures to be maximum estimates, and suspect that the global population may be much smaller. We include these estimates only to show that, even with figures obtained from high population density estimates, the estimated total number of bog turtles is still small. By these calculations, the bog turtle's estimated global population is smaller than the number of female Atlantic loggerhead turtles (*Caretta caretta*) nesting in the southern United States (14,000 to 29,000), or the global population of nesting female leatherback sea turtles (*Dermochelys coriacea*) (estimate of 120,000 at time of listing, but now down to 20,000-30,000). These sea turtles are listed respectively as Threatened and Endangered by USFWS (Federal Register; 40685, 11 August 1977: Federal Register; 8495, 2 June 1990).

Now, to look at these population figures more realistically, Dawson (1984) noted that "the majority of sites [in Maryland] were less than 1 acre (0.40 ha) in size." In North Carolina (by far the state with the largest population in the southern Appalachians) Tryon and Herman (1990) noted that most sites are from one to five acres in size (0.40 to 2.0 ha), and the average size was later calculated to be 1.06 ha for all colonies, and 1.47 ha for viable core habitats (Herman and Tryon 1993). Therefore, in two states where bog turtles are believed to be doing well, the average site has less than 2 ha of habitat. While the total number of currently occupied sites is unknown, the number may be smaller than the 227 figure presented in Table 2. In 1978 Chase et al. (1989) randomly selected and revisited 20 occupied sites identified in the original survey. In 25% of these sites no bog turtles were found. In a recent conversation with wildlife managers from the Maryland Department of Natural Resources we learned that by 1993 less than one half of the Taylor/Chase sites still supported turtles.

They also informed us that the site with the most turtles studied by Chase et al. (1989) had changed ownership, was no longer being grazed and multiflora rose was dominating the habitat. One 2 acre (0.8 ha) site that we have been monitoring in Maryland since the late 1960's had been completely lost through natural succession by 1991, and it seems likely to us that many of the Maryland sites identified in the mid-1970's have similarly deteriorated through succession. It is reasonable to assume that as few as 100 sites (and probably fewer than 25 colonies) are currently extant in Maryland.

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[1]Calculations on this and following pages are based on the numbers taken from publications cited in the previous text. While the numbers given by the U.S. Fish and Wildlife Service (1997) for the northern populations differ slightly (see Table 2), their figures would only increase the total number of extant sites by 5, and would not significantly change the results.

Table 2. Number of bog turtle sites, records and colonies recorded for each state within the range of this species. Information from various sources cited in text. Numbers given in parentheses under "Maximum Number of Extant Sites" are numbers of sites for northern states given by the U.S. Fish and Wildlife Service (1997), where their numbers differ from ours.

State	Total Number of Sites	Total Number of Records	Percentage of Total Records	Number of Counties with Records	Number of Counties with Extant Colonies	Maximum Number of Extant Sites	Minimum Number Viable Colonies
Rhode Island	1	1	0.16	1	0	0	0
Massachusetts	3	4	0.63	1	1	3	1
Connecticut	11	11	1.73	5	1	3 (5)	1
New York	77	77	12.09	8	6	6-12 (19)	6-12
New Jersey	75	122	19.15	17	12	12 (35)	2
Delaware	6	11	1.73	1	1	4	4
Pennsylvania	75	55	8.63	16	14	26 (34)	4
Maryland	177	203+	31.87	6	4	<100 (65)	<25
Virginia	23	43	6.75	4	3	13	2
North Carolina	70	99	15.54	18	16	48	29
Tennessee	2	2	0.31	1	1	2	2
South Carolina	3	4	0.63	2	2	1	0
Georgia	5	5	0.78	3	2	3	0
Totals	528	637	100%	83	63	227	<76

Population sizes estimated from mark-recapture studies are interesting, but we must keep in mind that Chase et al. (1989) captured only 229 turtles in a minimum of 240 site visits, and in Maryland's original intensive surveys of the mid-1970s only 346 turtles were found. The statistical calculations are an important contribution, but remember that these calculations represent predictions and not known numbers of turtles. Furthermore, a large percentage of the captures at many sites are old adults, raising the possibility that reproduction may not be occurring with regularity.

Bog turtles are neither randomly nor evenly distributed throughout the sites they occupy. We have studied a 1.62 ha sedge meadow in Maryland. Turtles ranged throughout this site, but were concentrated in a central core which occupied about 25% of the total area. Population densities in that 25% were high. If we made density estimates in the core area and used them to calculate densities for the entire site, we would produce a misleadingly high estimate of the number of turtles present. Experienced bog turtle researchers focus effort where the number of captures will be greatest, in places where the turtles are most likely to be found. Densities calculated for these areas should not be used to estimate density distribution throughout an entire site. Additionally, using radio telemetry Stine (unpublished) showed seasonal migrations within his study site. If these movements are not considered, mark-recapture estimates may be misleading because the original marked animals might later be in less carefully searched portions of the site, and not likely to be recaptured. We do not know how to factor these considerations to get a realistic assessment of total population, but the number is probably lower than estimated above. Considering an estimated minimum 25% rangewide habitat loss since the 1970's results in an estimate of only about 269 hectares of habitat and 179 sites throughout the entire range. Since there is no way to correct for possible bias with calculations of average number of turtles per site or turtles per hectare, we will use the previous density figures. Still, one must keep in mind that they are probably unrealistically high. For example, the large number of turtles at one Chase et al. (1989) site (213 individuals), which no longer exists, weighed heavily in their density estimates. If that site is not included in our calculations, the average density per occupied site becomes 39.5 turtles, a decrease of over 11%. The revised number of turtles calculated by average density per number of sites would be 7,912 (number of existing sites x 44.2 turtles per site). The number calculated by the reported average density per hectare is 11,890. It seems reasonable to us that the global population is somewhere between these last two figures, although one could argue that the calculations, because of overestimates of density, may be as much as 20 to 50% too high.

If one considers the number of historic sites now known to no longer support bog turtles, these population estimates are even more alarming. Particularly when we remember that many of those "historic" records date only from the 1960's and 1970's. For the few areas where there is enough information to document "historic" versus current occurrence, we find the following: Massachusetts, a 25% known loss; Connecticut at least a 75% loss; New York, a 45% loss with complete extirpation of one semi-relict population and another reduced to one site; New Jersey, 65% of historic sites lost; Delaware, about a 36% loss; Maryland, a 82.7% loss among 30 historic sites in less than 30 years, followed by a 43% loss of remaining surveyed sites in 15 years; Pennsylvania, at least a 50% loss of known sites and extirpation of the western disjunct populations; Virginia southward, only 50% of the total records now represent occupied sites (various regional reviews). Although these figures are crude (but conservative) we estimate at least a 50% average loss of known sites for this species throughout its entire range in a relatively short period. Add to this the fact that the majority of records (NY 13%, NJ 20%, PA 9%, MD 29% = 71% total) are from areas that are being rapidly developed.

Population Size.

Population size does not necessarily relate to the area available at a particular site, and some small sites support greater numbers of turtles than do some larger ones. In 1973 Ken Nemuras (in Cooper et al. 1973) estimated that there were about 50 "colonies" in Maryland with an average of 50 turtles per

colony. That estimate of the number of turtles per site proved to be quite accurate when compared to population estimates based on mark-recapture studies that were later conducted by Chase et al. (1989).

Detailed population estimates were made by Chase et al. (1989) at twenty sites in Carroll, Baltimore and Harford counties. The number of turtles at the sites studied ranged in estimated size from one to 230 ($\bar{x}$ = 44.2 individuals per site). Population density of turtles per ha ranged from seven to 213 ($\bar{x}$ = 58.77). Based on their figures, a crude estimate would indicate that seven to eight thousand bog turtles inhabited Maryland in the late 1970's (but see previous discussion). Because of habitat loss and succession, we suggest that there are fewer colonies in existence today and, based on an 82.7% loss of historic sites in less than a 30 year period, and the accelerated rate of land development, it is likely that only several thousand individuals currently inhabit Maryland. Recall that Maryland had a large number of sites, which in the late 1970's represented about half of the total known sites for the species (Table 2).

Collecting for Pet Trade

Unfortunately, the bog turtle, because of its small size, semi-terrestrial habitat, docile nature and unusually attractive appearance makes an ideal pet. This has always been a problem. Long before there were field guides and other books for the lay public on North American amphibians and reptiles, there was The Golden Nature Guide Series. In the reptile and amphibian volume of that series (Zim and Smith 1953) bog turtles were illustrated in an attractive terrarium and the text stated that "Turtle makes an excellent pet, eating chopped meat, earthworms, fruits and greens. It does not have to be fed in water, as do Spotted Turtles." In more recent versions of this book the illustrations and text do not emphasize captivity. As early as mid-1960, articles in the *Bulletin of the Philadelphia Herpetological Society* (Robotham 1963) were explaining the plight of bog turtle populations as they suffered from the pet trade and land use changes. Over the past three decades the problem has grown as the reptile pet trade has become a major business, and sky-rocketing prices have made international marketing very profitable. We are aware of considerable anecdotal information indicating that significant numbers of bog turtles have been, and still are being, shipped out of the United States, and the US Fish and Wildlife Service (1997) provided anecdotal and documented information on other instances of illegal collecting and export of this species for the pet trade, amounting to several thousand turtles.

The pet trade value of specimens has increased from about $100 an animal in 1973 to over $500 today. One 1992 add offered a pair of bog turtles for $1,500, and four adults were listed for sale at $750 per pair by a Florida animal dealer in that same year. With such high monetary value, it is difficult to protect colonies from poaching. Even acquisition of sites by bonafide conservation organizations does not guarantee protection from the pet trade. For instance, The Nature Conservancy acquired land in southeastern Pennsylvania because it contained a sizable colony of bog turtles. The site was the subject of population monitoring efforts and radio telemetry studies which showed a decline in population. Later, a researcher found approximately 60 turtle traps in the bog turtle habitat (L. Master, Memo Eastern Regional Office Nature Conservancy, 28 May 1992). This was clearly an illegal effort to obtain bog turtles by commercial collectors. Another regrettable incident happened during the summer of 1995 when the entire captive colony of bog turtles maintained at the Atlanta Zoo was stolen. Unknown persons entered the zoo grounds after hours and removed the turtles from their enclosure. Not only was this a very productive breeding colony, but it included some animals that had been in captivity for decades and had established longevity records. These turtles were part of a notable research effort, and the theft represents a loss of incalculable value. We are certain that these turtles were taken for sale to private collectors.

Land Ownership Patterns

As noted by Dawson (1984) the majority of Maryland's occupied sites are on private land. This, along with their disjunct micro-distribution patterns, makes individual bog turtle sites difficult to protect

from collecting and habitat alternation, and problematic to manage. State and federal agencies are reluctant or unable to spend funds for habitat management on private land, and the landowners themselves have little incentive to maintain bog turtle habitat unless it is being done through activities already adopted, such as grazing. We feel that effective management of private bog turtle habitat will require financial incentives to encourage land owners to protect colony sites. As will be mentioned later, this could be accomplished through tax advantages associated with conservation easements, particularly if funds were made available to purchase such easements from landowners.

Another problem may be landowner concerns over local, state and federal regulation of private land. We have spoken with several landowners who are concerned about the future of their bog turtle habitat, but are unwilling to work with state or federal agencies. In these instances, greater cooperation would result from contact initiated by a private or quasi-private conservation group working toward bog turtle conservation. Such a group could be a national or local conservation organization, or a local land trust.

Most bog turtle colonies are small and many are less than an acre in size. Natural succession proceeds at a rapid pace in such small habitat islands, and it is difficult and time-consuming to monitor scattered, small sites. Nevertheless, this species' long term well-being depends less on the protection of individual turtles than it does on protecting habitat to maintain viable populations. Small, isolated sites on private land will be impossible to maintain without the active participation of land owners. The scattered nature of bog turtle sites in Maryland, coupled with the fact that very few are on public land, makes it clear that the cooperation of private landholders must be a major element in any effective program to protect bog turtles.

Changing Land Use

As discussed previously, land use changes resulting from the "Europenization" of North America have resulted in several cycles of change that have affected the distribution and abundance of this small turtle. For instance, after the pre-colonial period and the local elimination of elk, bison and beaver (species that we believe were once key agents of bog turtle habitat maintenance), land clearing by colonists and grazing by farm stock probably kept many sites open. Prior to the widespread use of tractors early in this century, wet meadows were often maintained as grazing areas with horse drawn plows (Isaac McGee, owner of one of our study sites, pers. comm.). However, when heavy tractors and other modern farm equipment were introduced, they easily became stuck in the saturated soils of sedge meadows. Consequently, these areas were drained, or were avoided and no longer kept open by occasional plowing.

Another factor that may have been significant was the promotion of farm pond construction in the mid-1900's. Because of the types of habitat occupied by bog turtles, we suspect that many sites were converted to piedmont farm ponds. The springs and seepage areas that fed the sedge meadows became the water source for ponds as land owners converted this "unproductive" land to warm water impoundments. Circular basin type habitats fed by hillside springs would have been particularly easy to convert. These habitat types were considered by Chase et al. (1989) to be among the best sites for bog turtle colonies. Unfortunately, the steep edges of farm ponds limit the amount of emergent vegetation, and transitional areas between land and water tend to be abrupt. Because of this, farm ponds do not provide suitable habitat for bog turtles.

The area north of the Fall Line between Philadelphia, Wilmington and Baltimore is the region now most heavily populated with bog turtles. In this area there are more colonies than there are in the combined remainder of the species' range. Not only is the area highly urbanized and bisected by numerous interstate highways, but even the rural remnants of this region support a rapidly expanding maze of suburban environments. In the 1950's, for example, there were vast areas in Dulaney Valley and Potts Springs in central Baltimore County which provided almost continuous stretches of potential bog turtle

habitat. This habitat was lost to development long before the ecological requirements of bog turtles were recognized, but despite the lack of records we suspect that the area supported these turtles. There is not likely to be any significant decrease in the rate of expansion of suburban communities in the Philadelphia/ Baltimore area.

Another major change in land use throughout this region is exhibited by the dairy industry. From the colonial period through the late 1800's dairy animals were commonplace and were allowed to graze in small numbers on private farms throughout the piedmont of Maryland. In 1884 the first Maryland creamery was established. The industry was at first concerned primarily with butter production, but in the Baltimore-Washington area milk was shipped to cities for direct consumption. This trade, because of the limitations of then available refrigeration, was originally restricted to areas within a twenty-five mile radius of large cities, and Baltimore, Harford and Montgomery were the first major milk-producing counties in Maryland (Vokes 1968). The development of better roads, faster transportation and refrigerated trucks gradually widened the area from which milk could be shipped.

According to information provided by the Maryland Department of Agriculture (Maryland Agricultural Statistics, County Data, various years) the four Maryland counties known to support bog turtles (Baltimore, Carroll, Cecil and Harford) had 123,489 dairy and beef cattle in 1964. However, by 1980 that number had decreased to 37,450. That trend continued, and by 1991 those four counties had only 30,500 cattle. If the reduction in numbers of dairy and beef cattle in these counties continues at this rate, the role played by these large herbivores in maintaining open meadows will be eliminated in the near future.

We feel that the dairy industry was important because the grazing activity of dairy herds kept sedge meadow areas open. Many of the sites known to us in the 1970's were grazed by dairy animals and it was probably this activity that allowed bog turtles to continue to be rather common locally throughout that decade. The dairy industry was the last in a series of events (presence of bison/elk, land clearing during the colonial period, private subsistence farms, and dairy farms) that maintained the open, wet meadow habitats inhabited by bog turtles in this area.

One other major factor in the recent loss of local bog turtle habitat was an increase in property value that has made it difficult for property owners to maintain family farms. As agricultural land, these properties are taxed at a relatively low rate that has not risen significantly in recent years. However, increased housing needs coupled with the desire of persons in the Baltimore Metropolitan Area to move into the surrounding countryside has greatly increased the demand for single family homes and commercial centers in areas where bog turtles occur. Projections developed by the Maryland Office of Planning (1992) predict that the three Maryland counties supporting the greatest number of bog turtles (Baltimore, Cecil and Harford) will experience 91,305 acres of new development between 1990 and 2020, and that 46,294 of the acres converted to commercial and residential uses will be agricultural land. So, while the monetary value of this land as rural open space and agricultural land has remained relatively stationary, its value under subdivision has increased significantly. Several older individuals who presently own agricultural land with bog turtle sites have indicated to us their desire to retain the property in a rural state. However, they are concerned about the fate of this family farmland when it passes into the hands of their children. It would seem that this change in emphasis from agricultural to residential uses is coming at a time when the attachment of the younger generation to historic family land uses is weakening.

Some Solutions

The Maryland Nontidal Wetlands Protection Act, and implementing regulations, allow for historic agricultural practices to continue, including grazing and periodic burning to maintain pasturage. However, there seems to be some misunderstanding on the part of some local jurisdictions, and the owner of one bog turtle site told us that he had been informed that he could not continue to pasture his farm animals

in the wet meadow on his property, or burn it to discourage the growth of woody vegetation (specifically multiflora rose). This confusion emphasizes the need to merge ongoing efforts to manage bog turtle habitat with parallel efforts to protect wetlands. In addition, existing Maryland regulations allow for special consideration of wetlands having "exceptional ecological or educational value of Statewide significance" by designating them Nontidal Wetlands of Special State Concern. We feel that the ecologically diverse sedge meadow habitats currently occupied by bog turtles, and other rare species such as *Galium trifidum*, deserve such designation.

Although existing regulations seem to adequately protect such small nontidal wetlands within areas undergoing development, they would not ensure that these sites remain habitat suitable for bog turtles. For instance, a wetland within a property to be subdivided could be retained with a surrounding buffer. However, it is virtually certain that the surface and subsurface hydrologic changes resulting from adjacent grading and construction of housing units, roadways, utility lines and other appurtenances would result in a wetland unsuitable for bog turtles. We feel that preservation of bog turtle sites requires that they either be granted expanded protection under existing federal, state and local nontidal wetland regulations, or that other mechanisms be developed to effectively protect these isolated habitats and the aquifers that feed them. These mechanisms could include fee simple acquisition, protective zoning, and conservation or land preservation easements. Although current emphasis seems to be on fee simple acquisition, we suggest that this option should not be the primary tool used to protect this species. There are several reasons for this. In this time of fiscal austerity, state and federal acquisition money will become more scarce than it is today. In addition, large bureaucracies may be less sensitive to the needs of single species, and necessary action occurs more slowly. For instance, due to the nature of its established land acquisition process, the purchase of a typical property by the State of Maryland, once it is identified as a priority, takes from twelve to twenty four months (Diane Ramsey, pers. comm). Clearly, private conservation groups or other non-public organizations could act more quickly and efficiently where acquisition is indicated.

As of January 1, 1995, over 50 land conservation organizations operated in Maryland, including 41 local land trusts and two major state land preservation agencies. All of these exist for the sole purpose of preserving land in its natural state, or for agricultural or historic purposes, either by acquiring land or enacting deeds of easement or other legally binding restrictions. Including preservation of bog turtle habitat into these goals seems to us to be a logical extension of their ongoing activities. The Maryland Agricultural Land Preservation Foundation (Maryland Department of Agriculture) actively pursues acquisition of land preservation easements for agricultural lands. As of June 30, 1994, they had protected 109,909 acres throughout Maryland, including 336 properties comprising 42,065 acres in Baltimore, Carroll, Cecil and Harford Counties. The Maryland Environmental Trust (Maryland Department of Natural Resources) generally does not purchase easements, but does accept conservation easements donated by landowners. As of January 1, 1955, they had placed restrictive easements on a total of 41,250 acres throughout Maryland, including 106 properties comprising 11,117 acres in these same four counties. Both of these state agencies, and all pertinent local land trusts, could be enlisted in the effort to protect bog turtles. Establishing a group to identify appropriate habitat, submit those recommendations to a land preservation agency, and work to ensure that an appropriate easement is written and appended to the deed would be a very useful element of any local bog turtle preservation effort.

Preservation of bog turtles in Maryland will require protection of the sedge meadows that they inhabit, and the groundwater systems that feed them. In addition, these preservation areas should be strung together along drainage corridors to allow for natural movement of turtles between sites of occurrence. Where possible, historic habitat that has been modified should be included within these corridors and appropriate management should be initiated to return damaged areas to suitable habitat. This concept is fully consistent with the "Greenways" strategy now being developed by the Maryland Greenways Commission, and associated activities being conducted by the Maryland Department of Natural Resources, Maryland Department of Transportation, and other state agencies.

Although acquisition of habitat can be an effective preservation tool, this entire effort need not involve purchase of private property. In fact, considering that traditional private land management has been instrumental in maintaining bog turtles in this area, we suspect that most of the presently inhabited sites could, and perhaps should, remain in private hands. At the present time, only a few of the known sites are publicly owned. Since management of small, isolated patches of habitat would be difficult for any public agency with limited staff and resources, we suggest that acquisition by the state only be used where habitat is located adjacent to existing state land. Other areas could be protected most easily and quickly through an integrated program of regulatory control, protective zoning, conservation and land preservation easements. All of these are presently available, although no effort seems to have been made to use them to protect bog turtle habitat in this area.

Current Habitat Management

Habitat management for animals like bog turtles is relatively simple, but protecting wildlife and assessing the need for various levels of protection has become a complex business which involves private landowners, local, state and federal agencies. The exact location and size of extant populations cannot be published for fear that private and commercial collectors would raid colonies. To some extent this practice also hampers conservation efforts. Some of the information we present is vague and detailed maps showing known Maryland sites are not included because of our desire to discourage visitation. However, that effort is probably pointless. Using readily available published information, USGS quad maps and the latest Maryland distribution maps (Harris 1975), we feel that we would have little difficulty determining the location of many local sites supporting bog turtles. The same result could undoubtedly be obtained by anyone else who was equally motivated.

Several authors have pointed out the need for habitat management in order to maintain viable bog turtle habitat (Lee 1973, Tryon and Herman 1990). The most detailed treatment, presented by Tryon and Herman (1990), is for habitat in the southern Appalachians, and includes concurrent distributional surveys, density studies, landowner education, habitat protection, and captive breeding and headstart programs. Habitat management is essential for several reasons. Most obvious is natural succession. Most sites occupied by this turtle are small, 0.40 to 2.0 ha, and the characteristic open sedge meadows are easily swamped by invading woody vegetation. This process accelerates if the volume of groundwater seepage decreases, or if ponding or overland flow increases.

Tryon and Herman (1990) thought that in the southern bog turtle habitats studied by them, ecological succession was progressing at an increased rate. This may be a result of nutrient runoff from farmland, but this has not been demonstrated. Of primary concern is shading caused by alders, willows and red maples. These plants may also lower the water table through transpiration. Tryon and Herman prescribed pruning, burning, and grazing by small-to-moderate sized herds of cattle or horses to maintain suitable habitat, and noted that well over 50% of the existing bog turtle sites in the southern Appalachians are located in pastures actively grazed by these animals. In instances where succession of woody plants has occurred, unwanted vegetation could be removed by selective cutting (which is practical because of the small size of many colony sites), burning or grazing (Tryon and Herman 1990). Many small colony sites would also benefit from selective cutting of adjacent trees. This would not only improve the habitat, but cutting back the adjacent canopy could enlarge the area acceptable to bog turtles.

In addition to the natural succession of native species, the introduction of non-native species may also be a serious problem. For instance, the invasion of the introduced purple loosestrife (*Lythrum salicaria*) has altered the character of natural wetland communities in New York (Smith 1964). This exotic species could become a problem in other parts of the bog turtle's range, just as multiflora rose has done in Maryland. The Maryland Department of Natural Resources (Cooley 1994) has identified 56 invasive, exotic plants that occur on floodplains and in wetlands in Maryland. It is not known how many of these

regularly invade local bog turtle habitat, but the Carroll County site that we studied does support several plants on that list (halberd-leaved tearthumb, purple dead-nettle, Japanese honeysuckle, and multiflora rose).[2]

Management of areas where water tables have been altered, where springs were covered or capped, and where natural flow of water has been controlled would be difficult. In such places bog turtle colonies have disappeared or, at best, survive as remnants. Correcting local hydrology could be costly, difficult and probably not an efficient or effective tool for broad scale management. On the other hand, plant community management, where hydrology has not been altered, could be most effective. Systematic long range studies of the impact of habitat management on bog turtle population density would provide extremely useful information.

To ensure that site preservation and habitat management efforts are conducted effectively and efficiently, we recommend that active sites be monitored closely, and their status reviewed on a regular basis. All active sites should be photographed to allow periodic evaluation of successional change and permanent transects and botanical studies should be established in the more important localities. Property ownership and long range plans of property owners should be determined and cataloged, and property owners should be provided significant incentives to maintain habitat.

Current Legal Protection

Bog turtles are known from 12 states in eastern North American. The species was included by Groombridge (1982) in the IUCN Amphibian and Reptile Red Data Book (Pt 1:31-33) and listed as intermediate, but it is not yet listed as Endangered or Threatened by the U.S. Fish and Wildlife Service. However, Fish and Wildlife Service published a proposed rule to list the bog turtle as Threatened on January 29, 1997 (Federal Register 62[19]: 4229-4239). In that rule, the northern population (from New York and Massachusetts south to Maryland) would be considered Threatened, and the southern population (Virginia to northern Georgia) would also be listed as Threatened due to the similarity of its appearance to the northern population. The comment period extends to April 29, 1997. We assume that the currently available information on this species, combined with comments that will be submitted by interested persons, will lead to formal listing of the bog turtle sometime after that date.

Most states provide legal protection for this turtle under their existing nongame wildlife regulations, and it is listed in many of these states as Endangered or Threatened (Allen 1986). In Maryland the bog turtle was relisted as State Threatened by the Department of Natural Resources on October 24, 1994. As of that date possession of bog turtles without a special permit was prohibited in Maryland.

Even though the species is protected virtually throughout its range by state laws and regulations, there continues to be trafficking in wild caught turtles, particularly for international trade. Although the Lacey Act makes it illegal to transport illegally taken animals across state and international boarders, stronger legislative action is needed. Under CITES an export permit is required before a listed species can be sent out of the United States. The bog turtle was added to CITES Appendix II in 1975 (Honegger 1985). Because of the volume of trade in bog turtles, CITES upgraded the species from Appendix II to Appendix I on June 11, 1992. Federal protection under the Endangered Species Act would further protect the species from collectors. However, most collecting within their range is now illegal and it is becoming difficult for collectors to claim that turtles were obtained legally. Federal protection may not have the

[2]The magnitude of the problem posed by the invasion of introduced plant species is demonstrated by information provided by John Kartez from the Biota of North America Program housed at the North Carolina Botanical Garden. That database lists 784 introduced plant taxa for Maryland, fully 26.2% of the total flora.

advantage for bog turtles that it does for some other species because the majority of known colonies are on private lands. Because of this, "critical habitat" designations would not be practical. Modest enforcement by state agencies and the US Fish and Wildlife Service would effectively control legal commercial trade. However, illegal trade in reptiles is difficult to monitor and it is difficult to assess what impact commercial trade may continue to have if there is lack of vigorous enforcement. We feel that the high monetary value placed on bog turtles guarantees that a blackmarket trade in illegal animals will flourish.

While we believe that bog turtles deserve protection under the Endangered Species Act because of habitat loss and the impact of the pet trade, there is another issue which deserves discussion. Because the species is not yet federally listed, funding for land acquisition, population monitoring, land management and scientific study is less readily available. Limits on state revenues force most states to focus conservation resources on federally listed species. Unlike many species of plants and animals which are federally protected, a relatively small amount of effort is needed for protection and management of bog turtles. This is because of the small size and the nearly self-contained nature of the sites that they occupy, the inexpensive and effective means of controlling succession (pruning, fire, grazing), and the small size of the turtles themselves. We recognize that protection of only the site without protection of the larger watershed, is a potential problem for long-range stewardship. However, current water quality and sediment and erosion control laws and regulations are probably adequate, and many sites are largely self-contained on hillsides or in small basins, or have a very limited upstream drainage area.

Elaborate trapping, tracking and housing facilities like those needed for eagles or wolves would not be necessary for the bog turtle. The species is easily maintained and bred in captivity. While we recognize that being federally listed is a dubious form of notoriety, it is a valuable asset in terms of rallying the interest of individuals and conservation groups in long term protection . The additional legal penalties that are provided under the Endangered Species Act would also help reduce illegal pressure from the pet trade, and would mandate protection of bog turtle colonies found on federal lands.

Captive Propagation

Since captive propagation of bog turtles is presently being conducted successfully at several locations, we feel that the potential impact of this practice on commercial trade should also be considered. While we believe that protection of colonies and successional management of occupied sites is the best long range strategy for the preservation of this species, we also advocate captive breeding programs. Young produced by turtles from known localities could be used for restocking purposes, and for the preservation of genetic stock until protection, land acquisition and habitat management options can be put into place. Restocking programs could be used to start new colonies on protected state or federal lands, to re-establish extirpated colonies, or to add new "blood" to depleted colonies where inbreeding of small populations could lead to abnormalities. It is important for captive breeding programs not to mix stock if the release of captive bred turtles into the wild is planned. At the present time we know very little about the level of genetic difference between bog turtle populations. In fact, we do not even know if more than one taxon is present. To prevent a drain on native stocks, captive bred animals could be used for research purposes and for exhibit in zoos and nature centers.

Making it legal to sell or trade captive bred bog turtles does have some potential to adversely impact conservation efforts. If trade in bog turtles is totally prohibited, identification of illegally obtained turtles will be easier than if the sale of captive bred individuals is permitted. While most breeders and hobbyists are highly reputable, there will always be some individuals who will attempt to illegally market any animal having a high commercial value. Proposals to identify and track captive-bred or otherwise legally permitted animals are laudable, but probably not foolproof, at least with existing technology. Current emphasis is typically on microchip marking systems using passive integrated transponders (PIT's). These

devices are effective and accurate (Camper and Dixon 1988), but with the value of bog turtles pushing into the $500 to $1000 range, we suggest that the appearance of counterfeit or black market PIT tags is predictable. On the other hand, captive breeding projects could produce enough turtles to significantly reduce demand and market value, and if set up properly could generate funds to be used for habitat protection or acquisition.

Captive husbandry techniques for bog turtles are well established (Tryon and Hulsey 1972). Bog turtles were first bred by professionals in a zoo in 1973, but private individuals were successfully breeding this species as early as 1964 (Arford 1967, Eglis 1967, Galli 1978). Currently, there are at least eight institutions housing captive bog turtles, but only half of these are engaged in breeding programs (International Species Information System 1992). In the spring of 1992 Lee, in a cooperative agreement with the Maryland Department of Natural Resources, started a captive breeding program for this species using stocks from northern Carroll County, Maryland. Offspring from that effort are currently being loaned to zoos to expand captive breeding of Maryland bog turtles. Another successful captive breeding program involving Maryland bog turtles is presently underway at the Baltimore Zoo.

Acknowledgments

We thank Mary K. Clark (North Carolina State Museum of Natural Sciences), Carl Ernst (George Mason University), William Grogan (Salisbury State University), Dennis Herman (Zoo Atlanta), Donnell Redman (Natural History Society of Maryland), and Ann Sommers (University of North Carolina, Greensboro) for reviewing earlier drafts of this paper. Karl Krombein (National Museum of Natural History, Smithsonian Institution) provided access to the Plummers Island logbook maintained by the Washington Biologists' Field Club. Elmer Worthley, Jean Worthley, Tom Benassi and Donnell Redman assisted with the plant community analysis. John Kartez provided information on introduced plant species from the Biota of North America Program. David Stedman (Florida State Museum) and Charles Stine (Johns Hopkins University) granted permission for us to use their unpublished data. Tim Almager provided information on turtles in the collection of the Natural History Society of Maryland and William Grogan, Herbert Harris and Ken Nemuras discussed their many years of field experience with this turtle. Herbert Harris also granted permission to reprint the maps in Figure 3. A number of persons from the Maryland Department of Natural Resources provided useful information, including Glenn Therres and Scott Smith who shared information on this turtle's current status in Maryland, George Beston who discussed the Maryland Nontidal Wetland Protection Act, and Diane Ramsey who explained the State's land acquisition process. Robert Miller provided several distribution records and loaned us the Maryland specimen from the Towson State University collection on which Figure 2A is based. Renaldo Kuhler (North Carolina State Museum of Natural Sciences) prepared the illustrations. Cathy Wood typed the manuscript.

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Another Albinistic Painted Turtle (*Chrysemys picta*) from Maryland.

Arnold W. Norden

Although albinism in turtles seems to be an uncommon occurrence, albino individuals representing several taxa have been recorded (Dyrkacz 1981, Hensley 1959). In Maryland, the only complete or partial albinistic (Dyrkacz 1981) turtles reported are a hatchling snapping turtle (*Chelydra serpentina*) (Williams and Norden 1992) and a hatchling painted turtle (Cooper 1958). That painted turtle seems to be the only albino *Chrysemys picta* previously reported.

This note records an additional albino painted turtle, also from Maryland. The specimen reported here is a hatchling (shell 29 mm long and 24 mm wide), collected on 7 May 1988 at Jug Bay on the Patuxent River, Patuxent River Park, Prince Georges County, Maryland. The turtle was donated to the Clearwater Nature Center at Cosca Regional Park in Clinton, Maryland, where it lived in captivity until 3 August 1988. At the present time the specimen is part of a small preserved collection (uncatalogued) housed at the Clearwater Nature Center. The turtle, after eight years in formalin, is chalk white with no clear trace of pattern on the shell or skin. Both the shell and skin are virtually transparent, and the skull and dermal sutures are visible. Brenda McCelvin, who worked at the nature center at that time, told me that when this turtle was alive it was white, with no discernable trace of pigment. Photographs of the preserved specimen have been placed at the Natural History Society of Maryland.

Cooper (1958) stated that the albinistic painted turtle he reported was collected at "Marlborough, Marlborough Branch, Maryland" and gave the date as April of 1942. Like the specimen reported here, that turtle (USNM 116458) also measured 29 mm in length and was "chalk white in formaldehyde." Harris (1968) repeated the collection data as it was published by Cooper. However, Hensley (1959), in his synopsis of albinism in North American amphibians and reptiles, gave data for that specimen as follows: "Maryland, Prince Georges County, Upper Marlboro, Marlboro Branch, J. E. Cooper." The data given by Cooper is based on the entry in the original United States National Museum ledger, while the data given by Hensley reflects the modified entry in the new National Museum of Natural History catalogue (Jeremy Jacobs, pers. comm.), and gives the correct spelling of the collection locality. Since the names Marlborough or Marlborough Branch are not in use anywhere in Maryland (Maryland Department of State Planning 1978), and are not found on Prince Georges County maps predating the collection of this specimen, it can be assumed that the incorrect place names given in the original catalogue entry resulted from simple error. That specimen was brought to the National Museum by Ralph D. Tate.

Reference to recent and historic area maps also showed that no stream in Prince Georges County has been called Marlboro Branch. Jeremy Jacobs, in checking the original ledger entry, found that the place of capture was given as Marlborough Bridge, and not Marlborough Branch as cited by Cooper. That turtle was undoubtedly collected in Western Branch or one of its tributaries, in or near Upper Marlboro. Western Branch flows into the Patuxent River. The new specimen reported here came from the Patuxent River, at a location only about 7.5 km from the center of Upper Marlboro.

I would like to thank Sandra Lyon for providing access to the albino painted turtle preserved at the Clearwater Nature Center. John Zyla and Brenda McCelvin brought this interesting specimen to my attention, and provided information on its collection. Jeremy Jacobs kindly reviewed information on the Tate specimen recorded in the new Smithsonian catalogue and the original ledger.

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Survey of the Dragonflies and Damselflies (Odonata: Anisoptera and Zygoptera) of the Patuxent River Naval Air Station, St. Mary's County, Maryland

Kyle Rambo

This paper documents a survey of the dragonflies and damselflies of the Patuxent River Naval Air Station (PRNAS), St. Mary's County, Maryland. The Naval Air Station occupies approximately 7000 acres on the Western Shore of the Chesapeake Bay at the mouth of the Patuxent River. The initial focus of the survey was five species that are considered to be rare in Maryland by the Maryland Natural Heritage Program (1994). They were the Spatterdock Darner (*Aeshna mutata*), Sable Clubtail (*Gomphus rogersi*), Treetop Emerald (*Somatochlora provocans*), Elusive Clubtail (*Stylurus notatus*), and Gray Petaltail (*Tachopteryx thoreyi*). One of these, *A. mutata*, is listed as a State Endangered Species. The effort was expanded, however, to collect a sample of each distinguishable odonate found on the installation. Different forms collected were representative of different species or intraspecific variations due to age, sex, or distinct color morphs.

Habitats sampled included man-made freshwater ponds, beaver ponds, freshwater marshes, saltmarshes, woodland streams, springs and seeps, agricultural fields, weedy fields (abandoned agriculture parcels or other disturbed areas), pastures, woodland edges, and sandy beaches. Adults were collected with insect nets while they were roosting or in flight. Nymphs were collected with dip nets by sweeping the bottom of water bodies or vegetative cover in aquatic habitats. Each habitat was sampled several times during the May to September survey period, and at various times of the day. While many species of dragonfly or damselfly are strictly diurnal, others are known to be crepuscular or even nocturnal.

Adult dragonflies and damselflies were identified using Carpenter (1991), Dunkle (1989, 1990), Needham and Westfall (1955), and Walker (1953, 1954, 1975). Nymphs were either kept in captivity until adults emerged, or were forwarded to Richard Orr for identification. The following 41 species (10 damselflies and 31 dragonflies) were found at the Naval Air Station. Specimens of each are preserved and archived in the permanent Navy collection at PRNAS. The only rare species discovered, the Gray Petaltail, is represented by a single specimen collected by Charles Davis on 11 July 1996. Common names used follow the standardized list prepared by the Dragonfly Society of the Americas.

Dragonflies

Anax junius, Common Green Darner
Brachymesia gravida, Four-spotted Pennant
Celithemis elisa, Calico Pennant
Celithemis eponina, Halloween Pennant
Celithemis fasciata, Banded Pennant
Cordulegaster obliqua, Arrowhead Spiketail
Dromogomphus spinosus, Black-shouldered Spineyleg
Erythemis simplicicollis, Eastern Pondhawk
Erythrodiplax berenice, Seaside Dragonlet
Epiaeschna heros, Swamp Darner
Gomphus exilis, Lancet Clubtail
Libellula axilena, Bar-winged Skimmer
Libellula cyanea, Spangled Skimmer
Libellula deplanata, Blue Corporal
Libellula flavida, Yellow-sided Skimmer
Libellula incesta, Slaty Skimmer

Libellula luctuosa, Widow Skimmer
Libellula lydia, Common Whitetail
Libellula needhami, Needham's Skimmer
Libellula pulchella, Twelve-spotted Skimmer
Libellula semifasciata, Painted Skimmer
Libellula vibrans, Great Blue Skimmer
Pachydiplax longipennis, Blue Dasher
Pantala flavescens, Wandering Glider
Pantala hymenea, Spot-winged Glider
Perithemis tenera, Eastern Amberwing
Sympetrum ambiguum, Blue-faced Meadowhawk
Sympetrum vicinum, Yellow-legged Meadowhawk
Tachopteryx thoreyi, Gray Petaltail
Tramea carolina, Carolina Saddlebags
Tramea lacerata, Black Saddlebags

Damselflies

Amphiagrion saucium, Eastern Red Damsel
Argia fumipennis violacea, Variable Dancer
Calopteryx maculata, Ebony Jewelwing
Enallagma civile, Familiar Bluet
Enallagma traviatum, Slender Bluet
Ischnura hastata, Citrine Forktail
Ischnura posita, Fragile Forktail
Ischnura ramburii, Rambur's Forktail
Ischnura verticalis, Eastern Forktail
Lestes disjunctus australis, Common Spreadwing

The principal investigator in this study was Charles Davis. His careful planning, identification skills, coordination and training of novice odonate hunters, and tireless field efforts were largely responsible for the success of this project. Field personnel who assisted in the collection of specimens included Keith Clow and Sharon Frazey (both Resource Conservation Assistants with the Student Conservation Association), and Andrew Kijesky (summer-hire Biological Aid). Special thanks go to Mr. Richard Orr for his assistance in identifying difficult damselfly specimens. The survey was a cooperative effort between PRNAS and the Maryland Department of Natural Resources. It was funded by a grant from the Department of Defense Legacy Resources Management Program and executed as part of a broader cooperative agreement between PRNAS and the Maryland Department of Natural Resources for a comprehensive rare species survey.

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Sedge Marsh Butterflies Closely Associated with Bog Turtle Habitat

Richard H. Smith, Jr.

The wetland community providing ideal natural habitat for the Bog Turtle (*Clemmys muhlenbergii*), namely, sedge meadows below springheads or on bottomland, is also closely associated with two very local Maryland butterfly species, the Black Dash (*Euphyes conspicuus*) and the Mulberry Wing (*Poanes massasoit*). These species utilize Tussock Sedge (*Carex stricta*), a dominant sedge species in such habitats, as their sole larval host plant.

The Black Dash is a dark brown skipper butterfly in the subfamily Hesperiinae, with a wingspan ranging from 1.4 to 1.8 cm. The upperside has reddish-brown markings on the forewing and hindwing. The underside is dark orange-red with a dark yellow patch in the hindwing discal area. Males possess a long forewing stigma or scent patch, thus giving the species its common name. The Mulberry Wing is a mostly velvet-black skipper butterfly, also in the subfamily Hesperiinae, with a wingspan ranging from 1.4 to 1.6 cm. The male is uniformly black on the dorsal wing surface whereas the female has traces of yellow spots dorsally. The hindwing underside of both sexes is characterized by a large discal patch (sometimes invaded by a short rust-colored band) that contrasts with the otherwise dark brown to black coloration in this region of the wing.

Both species of butterfly are single brooded. The Black Dash flies from late June to early August, with the brood population peak in Maryland in early July. The Mulberry Wing emergence period follows the Black Dash by about a week, and it flies from late June to early August, with brood peak occurring in Maryland in mid July. Although the adult occurrence periods for the Black Dash and Mulberry Wing overlap by several weeks, their habits are so different that they rarely interfere with one another's activities. Adult males of the Black Dash perch on medium to low marsh vegetation, defend territories above their perches, and wait for and court wandering females that may fly into their territories. In contrast, Mulberry Wing males undertake a patrolling behavior for mate seeking, although their flight is weak, meandering, and occurs within a foot or so of the marsh surface in the breaks between fern and sedge tussocks. Perching, when indulged in by Mulberry Wings, occurs only on the lower strands of vegetation. Adults of both species have been observed necturing on Common Milkweed (*Asclepias syriaca*), Buttonbush (*Cephalanthus occidentalis*) and Swamp Milkweed (*Asclepias incarnata*), The larval stages of neither of these butterflies have been fully reported (Opler and Malikul 1992).

The Black Dash and Mulberry Wing both range from the northcentral to the northeastern regions of the United States, and within that area their contiguous ranges are each divided into two distinct segments (Opler and Malikul 1992). The westernmost population ranges of both species are centered around the Great Lakes and extend from northern Ohio (both species) west to northeastern Nebraska (Black Dash) and southeastern Dakota (Mulberry Wing). The separate northeastern populations extend from Maryland (both species), north through eastern Pennsylvania to Massachusetts (Black Dash) and southern Vermont and New Hampshire (Mulberry Wing). The range of the Bog Turtle in the northeast, as mapped by Lee and Norden (1996), approximates the eastern ranges of these two butterflies. This is probably due to the dependance of both butterflies and the Bog Turtle on marshy habitats supporting Tussock Sedge.

Another butterfly denizen and cohabitant of sedge meadows in Maryland is the Appalachian Eyed Brown (*Satyrodes appalachia*). The range of this species, however, is much broader (from Mississippi and the northern half of Florida to Wisconsin and Vermont), and the species is generally of more common occurrence. This wider range and more common occurrence may be due to its use of other species of sedge (e.g., Lake Sedge, *Carex lacustris*) as larval host plants (Opler and Malikul 1992), and the Eyed

Brown's adaptability to partially wooded as well as open marsh habitats. Unlike the other butterflies considered here, *S. appalachia* does not appear to be declining in Maryland at the present time.

Because of losses of sedge meadow habitat due to natural succession and human intercession (e.g., draining, filling, conversion to farm ponds, or encroachment by road or building construction), these butterflies, along with the Bog Turtle, are experiencing steady population declines and range shrinkages. The Black Dash has been designated as Vulnerable in Pennsylvania (Genoways and Brenner 1985) because of recorded disappearance of populations in that state. I have observed the decline or disappearance of many colonies of the Black Dash and Mulberry Wing in Maryland over the past 40 years. For instance, populations of these species that once occurred near Beltsville (Prince Georges County) and were described by Clark (1932), disappeared in the 1950's due to encroachment and succession to woodland. A colony at Harmans (Anne Arundel County), about ten miles north of the Beltsville site, and known to the author in the early 1970's, is now much diminished due to road and building construction. Another colony known to the author in the 1960's near Rocks State Park (Harford County) disappeared due to natural succession, and one other colony occurring at Daisy (Howard County) has declined considerably due to succession of the habitat from a sedge dominated profile to one dominated by Smooth Alder (*Alnus serrulata*), Common Cattail (*Typha latifolia*), and Halberd-leaf tearthumb (*Polygonum arifolium*). A second Howard County site along Upper Benson Branch, that was known to the author in the early 1980's, has been drained and filled for development.

Despite these losses, it is pleasing to know that good habitat supporting apparently healthy populations of these butterfly species still occurs at scattered locations in rural areas of northern Carroll and Baltimore Counties in Maryland. It is also encouraging to note that these marsh dwelling butterflies should also benefit from efforts to protect the threatened Bog Turtle.

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Carpophilus melanopterus Erichson (Coleoptera: Nitidulidae) a Yucca specialist

C. L. Staines

Abstract. The life history and distribution of the yucca specialist *Carpophilus melanopterus* is discussed. A mimicry complex involving *C. melanopterus* and the mirid bug *Halticotoma valida* is postulated. Maryland records for *C. melanopterus* are presented.

Most naturalists think of the yucca moth, *Tegeticula yuccascella* (Riley) (Lepidoptera: Incurvariidae) as one of the few insects which feed on *Yucca* spp. (Liliaceae). In fact, *Yucca* spp. are host to a number of different insects such as *Megathymus streckeri* (Skinner), *M. yuccae* (Boisduval & LeConte) (Lepidoptera: Hesperiidae), *Erinnyis ello* (L.) (Lepidoptera: Sphingidae), *Halticotoma valida* Townsend (Heteroptera: Miridae), *Puto yuccae* (Coquillett) (Homoptera: Pseudococcidae), *Situlaspis yuccae* (Cockerell) (Homoptera: Diaspidiae), *Targionia yuccarum* (Cockerell) (Homoptera: Diaspidae), *Scyphophorus yuccae* Horn (Coleoptera: Curculionidae), and *Carpophilus yuccae* (Crotch), *C. pallipennis* Say, and *C. melanopterus* Erichson (Coleoptera: Nitidulidae) (Murtfeldt 1903).

While in Owings, Maryland (Calvert County) on 10 June 1994 I noticed numerous red and black marked insects on the flowers of *Y. filamentosa* L. At first I assumed they were the yucca plant bug (*H. valida*) but a closer examination showed them to be a sap beetle (Coleoptera: Nitidulidae). Keying the beetle in Arnett (1973) and Parsons (1943) lead to *C. melanopterus*. Comparison with identified material in the Smithsonian Institution collection confirmed the identification.

Carpophilus species occur in all of the faunal regions in the world, with the majority being found in the tropics. There are presently 191 species worldwide and 32 in the United States (Williams et al. 1983).

The biology of *C. melanopterus* was studied by Connell (1956) and is summarized as follows. Adults emerge before the *Yucca filamentosa* flowers open and begin to feed on the buds. Mating begins after four to five days of feeding. Eggs are laid in adult feeding holes between the layers of the furled petals, hatching in one to three days. Larvae mine between the upper and lower epidermal layers of flower petals. If the petal is large enough, a larva may complete development in one petal. In most instances larvae mine two or more petals before completing development. They may also mine stamens and the ovary. The three larval instars develop in 12 to 18 days. Mature larvae drop from flowers and burrow into the soil to construct a pupal chamber. The pupal period lasts 10 to 11 days. Adults emerge the same year but do not leave the pupal chamber until the next spring. Connell (1956) described the larva and pupa of *C. melanopterus*.

I have seen specimens of *C. melanopterus* from Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Mississippi, Missouri, New Jersey, New York, North Carolina, South Carolina, Texas, Virginia, West Virginia, and Mexico. The species is probably found throughout the range of *Y. filimentosa* (Parsons 1943).

Maryland Records: Baltimore City: Homewood, 2 June to 15 July 1940. Calvert Co.: Owings, 10 June 1994. Charles Co.: Waldorf, 20 June 1996; White Plains, 06 June 1995. Harford Co.: Edgewood, 14 June 1969. Prince George's Co.: Cheverly, 21 June 1993; College Park, 11 June 1953; Riverdale 22 May 1985. Montgomery Co.: Potomac, June 1972. Queen Anne's Co.: Grasonville, 13 June 1995. St. Mary's Co.: Charlotte Hall, 15 June 1995.

The similarity between *C. melanopterus* and *H. valida* is striking. Both species are about the same size (4 mm.), have red and black aposomatic coloration and are probably part of a Batesian mimicry complex. Batesian mimicry involves a relatively edible, uncommon mimic and an inedible, common model. From the life history of the two species one would assume *C. melanopterus* to be the mimic and *H. valida* to be the model. Neither Connell (1956) nor Haviland (1945) nor Wheeler (1976) mentioned the similarity between these two species in their biological studies. From a review of the literature, no work has been done on this complex, so it's fair game for whomever would like to examine it.

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Contributions other that short notes may include a brief informative abstract. Payment of page charges is not required for publication in *The Maryland Naturalist*. However, if funds are available, assistance to offset publication costs would be welcome.

Subscription to *The Maryland Naturalist* comes with membership in the Natural History Society of Maryland. Information on the availability and cost of back issues will be provided on request.

NATURAL HISTORY SOCIETY OF MARYLAND, INC.
2643 North Charles Street
Baltimore, Maryland 21218

The Maryland Naturalist

The Natural History Society of Maryland

Volume 41, Number 1-2 January/June 1997

ISSN 0096-4158

The Maryland Naturalist

Volume 41, Number 1-2 January/June 1997

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: September 26, 1997

Cover Illustration: Specimens of the Tulip-tree beauty (*Epimeces hortaria*), one of Maryland's largest geometrid moths. The upper specimen (actual size 47mm) represents the typical form, while the lower specimen is a melanic male representing the form "carbonaria". Photographs taken by Robert S. Bryant of specimens from his collection. Upper specimen collected 15 July 1981 in Ten Hills, Baltimore City; lower specimen collected 7 August 1969 at Loch Raven, Baltimore County, Maryland.

The Looper Moths of Maryland (Lepidoptera: Geometridae)

Robert S. Bryant

Abstract: New county records are listed for 170 species of Maryland Geometridae. In addition, information is presented concerning a new foodplant, flight times and parasitism of unrecorded geometrid species.

With 170 species thus far recorded for Maryland, members of the family Geometridae comprise one of our largest families of macromoths, second only to the Noctuidae or owlet moths. Most geometers have slender bodies and broad, delicate wings. They range in size from 1 cm to 6 cm (wing expanse) and a few species have wingless females. Many are attracted to fermenting fruit and can be collected easily in a bait trap (Bryant 1978). Several species occur in sufficient numbers to be classified as serious forest and orchard defoliators. In fact, I have always found one of these, *Erannis tiliaria* (Harr.), in moderate to enormous numbers in November, even though Stevenson (1992b) indicated that it was scarce.

The larvae feed on a wide range of foodplants, from common lawn weeds like chickweed and dandelion to fruit trees, pines and hardwoods. They are usually called inchworms or loopers because of the caterpillar's habit of stretching out full length, grasping a twig or leaf surface with its front legs and drawing the hind part of its body up to them, thereby forming a loop. The larvae are also known as measuringworms, spanworms and dropworms. The latter name refers to a survival tactic. When at rest many larvae rely on their resemblance to broken twigs or pine needles to escape the notice of predators. But when danger threatens they will drop from their perch on a silken thread and become motionless several inches to several feet below their original position. When the danger has passed they laboriously wind the silk around their front legs and pull themselves back up to the leaf surface.

The incidence of melanism among many species of geometrids is quite high here in Maryland. For example, the *Epimecis hortaria* (F.) population in the Ten Hills section of Baltimore City is comprised of fully 50% of the melanic form "carbonaria" Haim. Over the years I have reared small broods of both the melanic form and normal form on *Lindera benzoin* (L.) (spicebush), a foodplant that is not listed by Covell (1984), Tietz (1972), Forbes (1948), or any of the other current authors who give extensive lists of foodplants for each species of moth. On several occasions I have even found wild *E. hortaria* larvae mixed in with *Callosamia promethea* (Dru.) larvae that I had caged out on a living spicebush. Sassafras is listed as a primary host plant for *E. hortaria* and since sassafras and spicebush are both members of the Lauraceae (Brown and Brown 1972) and share a similar aromatic quality, it is not surprising that spicebush would also be an acceptable host, but rather that it has gone unrecorded for so long.

On three occasions in July 1972, while collecting at UV light, I observed a common geometrid with one or more, partly to fully engorged, protelean parasites attached to its wing veins or thorax. One of them was a long legged acarine stowaway which appears to belong to the genus *Callidosoma*, possibly *C. treati* Southcott, as it has been taken here in Maryland, but only on Noctuidae (Treat 1975), and attached to the costal vein of the left forewing of *Anavitrinelia pampinaria* (Gn.). The other more numerous red mites, three on the inner margin of the left hind wing of *Thysanopyga intractata* (Wlk.) and two on the thorax of *Eupithecia miserulata* Grt., may prove to be members of the Trombidiidae. Professor Treat specialized almost exclusively on the mites infesting Noctuidae and, therefore, mites occurring on the Geometridae are largely unrecorded.

Many collectors who utilize UV light to attract moths do not realize that there is a slight change between the species seen in the early evening and those seen in the early morning. Several species only come to light in the hour preceding dawn and to take advantage of this characteristic one must either stay up all night or use a light trap. Two geometrids that are the most active during the pre-dawn hour are

Ennomos subsignaria (Hbn.) and *Metanema inatomaria* Gn. The first is relatively common, the second is decidedly scarce.

It may seem that winters in Maryland are too harsh to promote much moth activity, but actually there are several species of geometrids that are able to withstand lower temperatures. In November when the temperatures are regularly in the mid to upper thirties, *E. tiliaria*, *Alsophila pometaria* (Harr.) and *Orthonama obstipata* (F.) begin their winter activities. The first flies for only one or two weeks, but the last two may be found on warm nights for a month or more and may even still be found when the earliest spring species such as *Paleacrita vernata* (Peck) and *Phigalia denticulata* Hlst. begin to fly in late January or early February. In general, any night that is 36° F or warmer at dusk, will stimulate limited moth activity

All of the specimens listed below are contained in the Maryland Moth Survey collection, maintained by the author, regardless of the collector named. Except for a few specimens that were donated, more than a decade ago, virtually nothing has been reported to me since then. It is hoped that if anyone has species or county records not mentioned here, they will pass the information along to me so this list can be updated in a timely manner.

Entries followed by the number one in parentheses were reported by Stevenson (1992a, 1992b). A search of other literature dealing exclusively with the Geometridae yielded fewer than two dozen species credited to Maryland. Most of those reports gave no specific data, however; most of them are duplicated by, and covered in, the present list. The three species for which we have no additional records are included at the end of the list. The species followed by the number two in parentheses were mentioned in Packard's old (1876) monograph of the Geometridae, and the species followed by the number three in parentheses was given in Ferguson's more recent treatment (1985) of the green geometrids. To maintain consistency with the other parts of the check list of the moths of Maryland (Bryant 1981, 1982, 1995a, 1995b, 1995c, 1996) this segment follows the arrangement in the McDunnough (1938) check list, although the nomenclature has been updated to reflect that used by Covell (1984), Hodges et al. (1983) and other contemporary authors.

GEOMETRIDAE
OENOCHROMINAE

Alsophila pometaria (Harr.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 8-XII-80, 15-II & 23,27 & 29-XI & 2 & 24-XII-82, 17 & 18-XII-84 & 29-XI-91.
CARROLL: Reese, 10, 25 & 27-XI & 3-XII-67.

GEOMETRINAE

Nemoria lixaria (Gn.)
ANNE ARUNDEL: (1).
CALVERT: (1).

Nemoria saturiba Fgn.
ANNE ARUNDEL: (1)

Nemoria bistriaria Hbn.
ANNE ARUNDEL: Sherwood Forest, 27-VII-64.
BALTIMORE: Baltimore, Ten Hills, 13-IV-71, 23-IV & 1-V & 14-VI & 17, 19 & 21-VII & 2-VIII-72, 19-IV & 14,22,23 & 29-VII-73, 18-IV & 22-VII-74, 21-IV & 1-VIII-76, 1,6,8,13,23 & 25-VII & 13-VIII-80, 14-

IV & 9, 18,21 & 31-VII-81, 2-V & 14 & 24-VII-82, 8,17,19,20,21,24,27 & 28-VII & 3-VIII-83, 21 & 26-IV & 7,10 & 19-VII-85.
CALVERT: (1)

Nemoria rubrifrontaria (Pack.)
BALTIMORE: Baltimore, Ten Hills, 14-VII-70 & 2 & 21-VIII-71.
CHARLES: Ironsides, 15-V-75 collected by W.A. Andersen.

Synchlora aerata (F.)
ANNE ARUNDEL: Sherwood Forest, 27-VII-64.
BALTIMORE: Baltimore, Ten Hills, VIII-61, 5-VI & 13,18 & 19-VII & 18 & 30-VIII-66, 4-VII-68, 30-VI & 4-VII-69, 30-VI & 5-IX-70, 5-VI & 14 & 20-VII & 21-VIII & 8,9 & 29-IX-71, 2-VI & 17-VII & 23,26,27 & 28-VIII & 7 & 21-IX-72, 3,6 & 7-VI & 9,10,11 & 19-VII & 18,19 & 27-VIII & 17 & 27-IX-73, 15,16 & 18-VII & 26-VIII-80, 24-VI & 8-VII & 29-VIII-81, 14 & 16-VII & 25-VIII & 2,3,10 & 12-IX-82, 18-VIII-83 & 12-VII-85.
CARROLL: Reese, 24-VII-68.

Dichorda iridaria (Gn.)
ANNE ARUNDEL: (1).
CALVERT: (1)

Hethemia pistasciaria (Gn.)
ANNE ARUNDEL: (1)

Chlorochlamys chloroleucaria (Gn.)
ANNE ARUNDEL: Sherwood Forest, 27-VII-64.
BALTIMORE: Baltimore, Ten Hills, 19-VII-66, 14-V-68, 9-VII-71, 12 & 18-VIII-73, 4-VII-81 & 8-VII-82.
CARROLL: Reese, 24-VII & 31-VIII-68.

Chloropteryx tepperaria (Hulst)
ANNE ARUNDEL: (1)

STERRHINAE

Lobocleta ossularia (Gey.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 5-VII-85.

Scopula junctaria (Wlk.)
ANNE ARUNDEL: (1)

Scopula limboundata (Haw.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, VII-61, 12 & 14-VI & 7-VII-64, 7 & 12-VII-68, 20-VI & 9-IX-69, 8-VI-70, 5-VI & 28-VIII-71, 23-VIII-72, 9-VII & 2 & 7-IX-73, 18 & 25-VI-81 & 13-IX-84.
WASHINGTON: Seavolt Road, 2-VII-77.

Scopula inductata (Gn.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 22-V-74.
CARROLL: Reese, 21-IX-68.

Idaea demissaria (Hbn.)
BALTIMORE: Baltimore, Ten Hills, 24-VIII-69, 26-VIII & 5 & 7-IX-71.

Idaea obfusaria (Wlk.)
ANNE ARUNDEL: (1)

Idaea furciferata (Pack.)
ANNE ARUNDEL: (1)

Haematopis grataria (F.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 15 & 21-VI-64, 19-VI-66, 3,5,7 & 28-VIII-70, 3-IX-71, 23-VII & 12-VIII & 27-IX-72, 7 & 26-VIII-80, 3 & 16-VI & 29,30 & 31-VIII-81, 4 & 14-IX & 21-X-84 & 5-V-85. Soldiers Delight, 19-V-84.
CALVERT: (1).
CARROLL: Finksburg, 8-VII-73. Marriottsville, 24-VI-69.
DORCHESTER: Meekins Neck, 8-X-70.
HOWARD: Woodbine, 2-VI-65.

Calothysanis amaturaria (Wlk.)
BALTIMORE: Baltimore, Ten Hills, 26-VII-66 & 4-VIII-80.
WASHINGTON: Deneen Road, 4-V-74.

Pleuroprucha insulsaria (Gn.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 28-VII-66, 4-VII-68, 10-IX-69, 2-VIII-71, 14-VIII & 14-X-72, 9,13 & 14-VII & 11 & 13-IX & 4-X-73, 19-VII & 3-IX-80.

Cyclophora packardi (Prout)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 25-VI-70, 12-VIII-72, 23-IV & 19-V-73, 16-VI-81, 27-VI-83 & 5-V-85.
CALVERT: (1)

Cyclophora pendulinaria (Gn.)
ANNE ARUNDEL:(1).
BALTIMORE: Baltimore, Ten Hills, 15-VI-81, 1-V-85 & 14-V-93.
CARROLL: Reese, 22-V-68.

form "nigricaria" (Rothke)
BALTIMORE: Baltimore, Ten Hills, 26-V-84.

LARENTIINAE

Cladara limitaria (Wlk.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 30-IV-82.

Cladara anguilineata (Grt. & Rob.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 21 & 22-IV-73 & 30-III-77.

Cladara atroliturata (Wlk.)
CALVERT: (1)

Lobophora nivigerata Wlk.
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 14-V-68.

Heterophleps refusaria (Wlk.)
WASHINGTON: Deneen Road, 4-V-74.

Heterophleps triguttaria H.-S.
ANNE ARUNDEL: (1).
FREDERICK: Catoctin Mountain Park, 24-VI-83.
HOWARD: Evergreen Valley, 28-VIII-73.

Dyspteris abortivaria (H.-S.)
ANNE ARUNDEL: Harwood, 19-IV-76.
BALTIMORE: Baltimore, Ten Hills, 26-VII-66, 18-VII-68, 9,13 & 17-VII-69, 13 & 25-VII-70, 6 & 11-VII-71, 31-VII-72, 13 & 20-V & 2,8,23 & 24-VII-73, 12-VII-74, 4-VIII-75, 14,17 & 23-VII-76, 12 & 16-VII-80, 26-V & 8,9 & 19-VII & 29-VIII-81, 3-VI & 15 & 18-VII-82, 12-VI & 6,8,16,20,21,26,27 & 28-VII-83,9, 14 & 16-VII-84, 15 & 26-V & 4,9,10 & 16-VII-85, 4-VII-86 & 8-VII-91. Lutherville, 27-VII-66 collected by W. A. Andersen.
CALVERT: (1).
CARROLL: Reese, 3-VI-68.
WASHINGTON: Seavolt Road, 17-VII-74.

Trichodezia albovittata (Gn.)
CALVERT: (1).
CARROLL: Reese, 26-V-67.
GARRETT: Accident, 20-V-71. Grantsville, 11-V-61 collected by W.A. Andersen, & 20-V-71.

Hydria prunivorata (Fgn.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, 13-VIII-68, 2-VI-75, 21-VI-80, 23,27,28,29 & 30-VI & 1,8 & 18-VII-81, 12-V-85 & 21-V-95 (sight record).

Coryphista meadii (Pack.)
ANNE ARUNDEL: (1).
BALTIMORE: Baltimore, Ten Hills, VIII-60, 8 & 12-V & 15-VI-64, 12-IX-68, 21-VIII & 8 & 12-IX-70, 20 & 26-V & 13 & 24-VIII-71, 5-IX-72, 7-V & 27-VIII-73, 3-VII & 7 & 8-VIII-79, 19-VIII-80, 12-V & 25-VI & 3 & 10-VII & 16-VIII & 8 & 10-IX-81, 6-VIII-82, 10-V-83, 8-VII-84 & 1-V & 29-VI-85.

Eupithecia miserulata Grt.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 12-V-64, 17-IX-70, 12-IV-71, 19-VII-72 (mites), 2,12 & 20-IX-73, 12-X-74, 19-IV & 11 & 13-VI-76, 5 & 12-V-77, 10-IV & 20-IX-81, 2-V-82, 29-IV & 23-V-83 & 26-IV & 13 & 19-IX & 10-X-84.

Eupithecia palpata Pack.
BALTIMORE: Baltimore, Ten Hills, 9 & 28-V-73 & 13-V-83.

Eupithecia columbiata erpata Pears.
BALTIMORE: Baltimore, Ten Hills, 9-V-71 & 22-IV-77.

Eupithecia russeliata Swett
BALTIMORE: Baltimore, Ten Hills, 28-V & 12-VI-76 & 3-VI-77.

Eupithecia indistincta Tayl.
BALTIMORE: Baltimore, Ten Hills, 29-IV-72 & 22-IV-73.

Eupithecia coagulata Gn.
BALTIMORE: Baltimore, Ten Hills, 17-IX-70.

Eupithecia pusillata interruptofasciata Pack.
BALTIMORE: Baltimore, Ten Hills, 18-XI-66 & 10-XI-84.

Eupithecia swetti Grossb.
BALTIMORE: Baltimore, Ten Hills, 14-V-68 & 30-IV-81.

Horisme intestinata (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 7-VI-65, 29-VIII & 1-IX-68, 20,21 & 23-VIII & 10-IX-69, 28-V & 19-VI & 23 & 28-VIII-70, 14-VI-71, 4-VI-73, 2-IX-80, 17-VI-81 & 3-VI-82.

Eulithis diversilineata (Hbn.)
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Ten Hills, VII-61, 7-VII-64, 8-VII-65, 17 & 27-VII-68, 25-VIII & 21-IX-70, 10-VII-81, 14-VII-82, 30-VII & 12-X-84 & 5-VII-85.

Eulithis gracilineata (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 13-IX-69, 9-IX-72, 15-IX-74, 4-IX-76 & 8-VII-86.
CALVERT: (1)

Eulithis molliculata (Wlk.)
BALTIMORE: Baltimore, Gwynn Oak, 28-VI-65 collected by F.H.Chermock. Ten Hills, 7-VII-66.

Ecliptopera atricolorata (Grt. & Rob.)
ALLEGANY: Stottlemyer Road, 15-VII-71.
ANNE ARUNDEL: (1) .

Dysstroma hersiliata (Gn.)
FREDERICK: Catoctin Mountain Park, 24-VI-83.

Hydriomena pluviata meridianata McD.
ALLEGANY: Town Hill, 27-IV-74.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 12-V-64, 4-V-65, 3 & 20-V-66, 4-V-68, 29-IV-70, 10 & 19-V-71, 29-IV & 5-V-72, 6,22 & 24-IV & 13-V-73, 16-IV-74, 18-IV-76, 10-IV-81, 24 & 25-IV & 3 & 10-V-82, 27IV-83 & 1-V-84.
CALVERT: (1)
CARROLL: Reese, 17-IV-68.
WASHINGTON: Sideling Hill, 20-IV-77.

Hydriomena transfigurata Swett
ANNE ARUNDEL: (1)

Hydriomena renunciata (Wlk.)
ANNE ARUNDEL: (1)

Xanthorhoe lacustrata (Gn.)
ANNE ARUNDEL: Sherwood Forest, 1-VIII-73.
BALTIMORE: Baltimore, Ten Hills, 20-V-66, 4 & 14-V-68, 21-V-70, 13-IV & 17-VII-71, 17-IV & 5-X-72, 21 & 24-IV & 2-V & 7-IX-73, 20-IV & 9-VI & 16-VII-76, 11-IV & 19-V-77, 8-VII & 10-VIII-80, 11-

IV & 23-V & 24-VI-81, 21-VI & 22-VII & 22-VIII-82, 22-IV-83, 11-IV & 13-VIII & 1 & 12-IX-84, 26-V-85 & 4-VIII-90.
CALVERT: (1)
CARROLL: Finksburg, 22-VIII-73.
HOWARD: Evergreen Valley, 28-VIII-73.

Xanthorhoe packardata McD.
BALTIMORE: Baltimore, Ten Hills, VIII-63.

Xanthorhoe ferrugata (Clerck)
BALTIMORE: Baltimore, Ten Hills, 18-VIII-80.

Euphyia unangulata intermediata (Gn.)
BALTIMORE: Baltimore, Ten Hills, 28-V-75 & 31-V-83.

Orthonama obstipata (F.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 26-IV-65, 28-VIII & 4-IX-68, 28-VI & 1-VII & 10-IX & 4-X-69, 21-V & 22-VII & 2,3 & 19-VIII-70, 19-IV & 10,11,15 & 17-V & 3,5,7,17,22 & 29-VI & 5,17 & 20-VII & 2-VIII & 3 & 20-IX & 15-XII-71, 2-III & 12 & 16-IV & 5-V-72, 22-IV & 17-VIII & 19-IX-73, 22 & 25-IX & 1 & 26-X-84.

Orthonama centrostrigaria (Woll.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 26-IV & 7-VI-65, 11-V & 5 & 6-VI-69, 24-VIII & 2-IX-70, 10,14,17, 19, 21 & 24-V & 3,5 & 13-VI & 17-VII & 15-IX & 16-XII-71, 5 & 12-V & 15,28 & 30-VI- 72, 2 & 6-VI-73, 19-VI-83, 15-VIII & 12-IX & 24-X-84 & 16-V-85.
CALVERT: (1)

Anticlea multiferata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 10-V-65, 21-V-70, 8 & 31-V & 4-VI-71, 11-VI-76 & 14-V-81.

Anticlea vasiliata Gn.
ANNE ARUNDEL: (1)

Disclisioprocta stellata (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-VIII-64, 4-X-66, 4-X-69, 12-VIII & 5-IX-73, 7-IX-81, 6-VIII & 23-IX & 11 & 12-X-84.
CALVERT: (1)

Rheumaptera hastata (L.)
ANNE ARUNDEL: Stony Run, 4-VII-82 collected by W.A.Andersen.

Venusia comptaria (Wlk.)
BALTIMORE: Baltimore, Ten Hills, 2-V-82.

Hydrelia lucata Gn.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

Hydrelia inornata (Hulst)
BALTIMORE: Baltimore, Ten Hills, 27-VI-80.

Eubaphe mendica (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-VI-64, 18-VI-81, 25-V-82, 27-VIII-83.
CALVERT: (1)
CARROLL: Marriottsville, 24-VI-69.

Eubaphe meridiana (Slosson)
ANNE ARUNDEL: (1)
CALVERT: (1)

ENNOMINAE

Lomographa semiclarata (Wlk.)
ALLEGANY: Fifteen Mile Creek Road, 20-IV-77 & 26-IV-8l.
BALTIMORE: Baltimore, Ten Hills, 10-IV-81.
CARROLL: Reese, 17-IV-68, 14 & 26-IV & I-V-69 & 22-IV & 2-V-70.
GARRETT: Accident, 20-V-71.
HOWARD: Woodbine, 30-IV-65 & 30-IV-70.

Lomographa vestaliata (Gn.)
ALLEGANY: Ridge Road, 30-IV-77. Green Ridge State Forest, 13-V-72 & 4-V-74.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 13-VI-76, 6-V-77, 14-VII-83, 24-VI-85 & 8-VII-86. Catonsville- UMBC, 8-VI-74.
CALVERT: (1)
CARROLL: Reese, 22-IV-73.

Lomographa glomeraria (Grt.)
ALLEGANY: Green Ridge State Forest, 15-IV-82 collected by J.H.Fales.

Cabera erythemaria Gn.
BALTIMORE: Baltimore, Ten Hills, 21-V-85.

Erastria coloraria (F.)
CARROLL: Reese, 17-IV-68 & 14-IV-69.

Mellilla xanthometata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 29-VII-71, 13-VII-73, 23-VII-80, 6-VIII & 2-IX-84.
WASHINGTON: Seavolt Road, 2-VII-77.

Heliomata infulata (Grt.)
GARRETT: New Germany, 13-VII-78 & 12-VII-79 collected by W.A.Andersen.

Heliomata cycladata Grt. & Rob.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 12,14 & 21-VI-64, 25-VI-65, 5,15,19 & 23-VI-66, 7-VI-68, 25 & 30-V & 6 & 10-VI-69, 22,23 & 28-V-70, 15-V-71, 1-V-74, 31-V-75, 23-IV & 27-V-77 & 4-VI-81. Catonsville- UMBC, 10-VI-71 & 8-VI-74.
CALVERT: (1)
CARROLL: Camp Hashawa, 7-VI-81 collected by P.J.Kean.
WASHINGTON: Deneen Road, 20-IV-77 & 26-IV-81.

Semiothisa aemulataria (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 28-VII-66, 4-VI & 13 & 27-VII-71, 13 & 23-VIII-72, 22 & 24-IV & 15 & 22-V & 6-VI & 10 & 13-VII-73, 29-VI & 17 & 29-VII-76, 9-VII-81, 4 & 5-VIII-82, 22-IV-83 & 6-V-85.
CALVERT: (1)

Semiothisa aequiferaria (Wlk.)
CALVERT: (1)

Semiothisa promiscuata Fgn.
ANNE ARUNDEL: (1)

Semiothisa bisignata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 3-VIII-65, 29-VIII-68, 6-IX-70, 17-VII & 19,22,25 & 28-VIII-71, 27 & 28-VIII & 23-IX-72, 20-IX-73, 9 & 15-VI-76, 28-VI & 18 & 26-VIII & 2-IX-80, 7 & 8-VI & 15 & 29-VIII & 10-IX-81, 2,14,15 & 24-VIII-82 & 19-VI & 14-VIII-84.

Semiothisa bicolorata (F.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 22-VI-69, 11-VI-70, 13-VIII-72, 29-VIII & 4-IX-81 & 14-VIII-84.

Semiothisa transitaria (Wlk.)
ANNE ARUNDEL: (1)

Semiothisa multilineata (Pack.)
ANNE ARUNDEL: (1)
CALVERT: (1)

Semiothisa granitata (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 14-VI-64, 7-VII-68, 21-VI-71, 8-VI & 2-IX-73, 27 & 29-VI & 10-IX-81.
CALVERT: (1)

Semiothisa fissinotata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 23-VIII-71, 15-VIII-73, 6-VI & 27-VIII-81, 10,14,24 & 31-VIII & 10-IX-82, 23 & 27-V-83, 19-VI & 8-VIII-84 & 22-IV & 22,26,27 & 30-V & 10 & 25-VI-85.

Semiothisa pinistrobata Fgn.
BALTIMORE: Baltimore, Ten Hills, 16-VI-81.

Semiothisa continuata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 20-IV-76 & 11-VII-80.

Semiothisa ocellinata (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 8-V-64, 4-V-65, 12,17 & 25-VII-68, 11 & 17-V & 8,9 & 24-VI & 17-VII & 23-VIII-71, 5-V-72, 23-IV-73, 29-VI & 30-VIII-81 & 2 & 10-V-83.
CALVERT: (1)

Semiothisa gnophosaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 28-VII-66, 14-VI-70, 26-VI & 6-VII-71, 23-VII-72, 25-VII & 31-VIII-80, 30-VI & 23-VII-81, 14 & 28-VII-82 & 27-VII-83. Catonsville- UMBC, 10-VI-71.

Itame pustularia Gn.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 7-VII-68, 6 & 20-VI-69, 25-VI-71, 16-VI-72, 8-VII-81 & 17-VI-82.
CALVERT: (1).

Itame ribearia (Fitch)
GARRETT: Bittinger, 19-VII-81 collected by W.A.Andersen.

Protitame virginalis (Hulst)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 4-VI-83.

Hesperumia sulphuraria Pack.
WASHINGTON: Stone Cabin Gap, 7-VII-66 collected by W.A.Andersen.

Eufidonia notataria (Wlk.)
ALLEGANY: Fifteen Mile Creek Road, 30-IV-77.

Hypagyrtis unipunctata (Haw.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 23-V & 22,23 & 28-VII & 2 & 5-VIII-70, 30-VII & 9 & 20-VIII-71, 18-VII & 1,8 & 12-VIII-72, 23 & 29-VII & 6 & 12-VIII-73, 5-VIII-80, 25-V & 15 & 19-VII & 11 & 31-VIII-81, 15-V & 22 & 28-VII & 20 & 21-VIII-82, 25 & 31-V & 25 & 27-VII & 8-VIII-83, 30-IV & 6,16,20,23 & 27-V & 8,12,16 & 28-VII-85.
CALVERT: (1)
CARROLL: Reese, 19-VIII-67 & 3-VI & 12-VIII-68.

Hypagyrtis esther (Barnes)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 12-VIII-84.

Melanolophia canadaria (Gn.)
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Ten Hills, VII-61, 8-V & 18-VII-64, 26-IV & 23-VII-65, 20-V & 5-VI-66, 6-V & 7 VII-68, 7-VII-70, 17 & 22-IV & 23-VI & 23-VII-73, 11 & 29-VI & 3-VII-81, 27-IV-83 & 30-VII-90. Catonsville, 10-VIII-65.
CALVERT: (1),

Melanolophia signataria (Wlk.)
ALLEGANY: Green Ridge State Forest, 26-IV-81.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-IV-69, 29-IV-70, 6-V & 18-VIII-71, 29-IV-72, 21-IV-76, 27-V-81, 20 & 30-IV & 3-V-82, 27-IV-83, 1-V-84 & 5 & 30-IV-85.
CALVERT: (l)
CARROLL: Reese, 20-VII-68.

Protoboarmia porcelaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 27-V-85.

Cleora sublunaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 1-V-72, 21 & 24-IV-73, 23-IV-76, 9-IV-81, 27 & 28-IV-82 & 29-IV-83.
WASHINGTON: Sideling Hill, 20-IV-77.

Cleora projecta (Wlk.)
ANNE ARUNDEL: (1)

Hypomecis umbrosaria (Hbn)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-VI-69 & 22-V-85.
CARROLL: Reese, 29-VI-68.

Glena cribrataria (Gn.)
ANNE ARUNDEL: (1)

Anavitrinella pampinaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 8-V-64, 20-V & 5-VI-66, 7,10 & 17-VII-68, 17-VII-70, 4-VI & 18,27 & 30-VII & 2 & 10-VIII-71, 10-VII-72 (mite), 29-V & 9 & 23-VII-73, 18-VIII-80, 30-VI-81, 22-VII-82 & 6-VII-85.
CALVERT: (1)

Iridopsis larvaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-VI-66, 27-VII & 10-VIII-71, 1-VIII-72, 15-V & 9 & 23-VII & 5-VIII-73, 11-VII-81, 22-VII & 14-VIII-82 & 6-V-85.
CALVERT: (1)
CARROLL: Reese, 6-V-70.

Anacamptodes defectaria (Gn.)
ANNE ARUNDEL: (l)
BALTIMORE: Baltimore, Ten Hills, 30-VII-71, 5,12 & 14-VIII-72, 29-VII & 4-VIII & 20-IX-73, 15-VI & 27 & 30-VII & 4-IX-76, 5-VIII-77, 30-VII-80, 21-VII & 4-VIII & 4-X-81.
CALVERT: (1)

Anacamptodes humaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-V-70, 12-V-71, 17-VII-81, 28-VII & 14-VIII-82, 1 & 26-V & 3-VI-85.
CALVERT: (1)

Anacamptodes vellivolata (Hulst)
ANNE ARUNDEL: (1)
CALVERT: (1)

Anacamptodes pergracilis (Hulst)
CALVERT: (1)

Aethalura intertexta (Wlk.)
ANNE ARUNDEL: (1)

Ectropis crepuscularia (D. & S.)
ANNE ARUNDEL: (1)

BALTIMORE: Baltimore, Ten Hills, 26-VII & 6-VIII & 3-IX-71, 15-III-73, 30-VI & 5-VII-85.
CALVERT: (1)

Epimecis hortaria (F.)
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Ten Hills, VII-61, 21-VI-66, 17-VII-68, 14 & 28-VII-70, 16-V & 3-VII & 13-VIII-71, 4-V & 14-VI & 9 & 17-VII-72, 14-VII & 9-VIII-73, 8-VIII-74, 16-IV & 9-VI-76, 20-IX-79, 10-VII-80, 5 & 15-VII-81, 14-VI-82, 10-VI-85. Loch Raven, 26-VI & 4-VIII-69 & 21-VI-71. Owings Mills, 30-VI-67.
CALVERT: (1)
FREDERICK: Catoctin Mountain Park, 24-VI-83.
WASHINGTON: Sandy Hook, 21-IV-77 collected by W. A. Andersen. Seavolt Road, 20-IV-77.

form "carbonaria" Haim.
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Gwynn Oak, 5-X-61 collected by F.H.Chermock. Homeland, 4-VII-71. Ten Hills, VII-60, VIII-61, 6-VII & 10-VIII-65, 7-VII-68, 12 & 20-VII & 13-VIII-69, 23-V & 17-VII-70, 24-V & 20-VII & 2-VIII-71, 13-X-74, 16-IV-76, 26-VII-81, 10-V & 20-VI-83, 19-V-84 & 22-IV-85. Loch Raven, 7-VIII-69 & 22-VI-70.

Nacophora quernaria (J.E.Sm.)
ANNE ARUNDEL: Sherwood Forest, 10-VIII-64.
BALTIMORE: Baltimore, Ten Hills, 11-VI-71 & 10-VI-81.
CALVERT: (l)
CHARLES: Ironsides, 15-V-75 collected by W.A.Andersen.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

form "atrescens" Hlst.
WASHINGTON: Sideling Hill, 20-IV-77.

Phigalia strigataria (Minot)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 7 & 19-III-74, 21-III-79, 28-III & 2-IV-81 & 14-III-82.
CALVERT: (1)

Phigalia denticulata Hlst.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Gwynn Oak, 22-III-66. Ten Hills, 21-III & 3 & 5-IV-72, 8,13,14 & 15-III-73, 18-II & 24-III-81 & 13-III-82. Lutherville, 26-I-67 collected by W.A.Andersen.
CALVERT: (1)

Phigalia titea (Cram.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-III-62, 13,15,22,24,29 & 30-III & 1,2 & 3-IV-81, 13,14,19,21,22 & 23-III & 1 & 2-IV-82, 4,15,19 & 20-III & 3,5,7,21,22,26 & 27-IV-83, 8,10 & 11-IV-84.
CALVERT: (1)
PRINCE GEORGES: Beltsville, 17-III-83 collected by J.H.Fales.
WASHINGTON: Sideling Hill, 15-IV-82 collected by J.H.Fales.

form "deplorans" Franc.
BALTIMORE: Baltimore, Ten Hills, 15-III-73 & 16-III-83.

Paleacrita vernata (Peck)
BALTIMORE: Baltimore, Gwynn Oak, 20-III-64 & 22-III-66. Leakin Park, 26-II-65. Ten Hills, 15-III & 27-XII-71, 29-II & 1,2,7,12,18 & 19-III-72, 13-III-73, 5 & 7-III-74, 18 & 27-II & 1-III-81, 15 & 23-II & 17-

III-82, 31-I & 1,20 & 21-II & 2 & 3-III-83 & 16 & 24-II-84. Lutherville, 26-I-67 collected by W.A. Andersen.

Paleacrita merriccata Dyar
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 1 & 25-III-81 & 13-III-82.
CALVERT: (1)

Erannis tiliaria (Harr.)
BALTIMORE: Baltimore, Ten Hills, XI-60, XI-61, 14,22 & 26-XI & 1-XII-80, 5,8,9,10,11,12,13,14,16 & 18-XI-81, 10,11,12 & 20-XI-82, 6,7, 19,22 & 23-XI-83.
CALVERT: (1)
CARROLL: Reese, 10,11,18,25,26 & 27-XI & 3-XII-67.

Thysanopyga intractata (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 10-VIII-70, 4-VII-71, 9,10,13 (mites),14 & 18-VII & 12 & 29-VIII-72, 2 & 13-VII-73, 31-VIII-82, 27-IV-83, 25-VI & 5-VII-85 & 29-VIII-90.
CALVERT: (1)

Biston betularia cognataria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 23-VIII-72,.17-VII-73, 1-VIII-80, 1 & 24-VIII-83 & 17,18 & 21-VII-85.
CARROLL: Finksburg, 22-VIII-73. Reese, 28-VII-72.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

form "swettaria" (B. & McD.)
ALLEGANY: Flintstone, 1-VIII-62 collected by F.H.Chermock.
BALTIMORE: Baltimore, Ten Hills, 24-VIII-70, 5-VIII-72, 12 & 31-VIII-73 & 27-VII-85.
CARROLL: Marriottsville, 24-VI-69. Reese, 28-VII-72.
GARRETT: Carey Run, 9-VII-82 collected by P.J.Kean.

Eugonobapta nivosaria (Gn.)
GARRETT: The Glades, 19-VII-81 collected by W.A.Andersen.

Lytrosis sinuosa Rindge
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 23-VI-78.

Lytrosis unitaria (H.-S.)
ALLEGANY: Green Ridge State Forest, 6-VII-82 collected by J.D.Glaser.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Gwynn Oak, 25-VI-65. Ten Hills, 13 & 20-VI-70, 19-VI-71, 13-VI-76, 27-VI-80 & 6-VI-82. Loch Raven, 28-VI-71. Owings Mills, 30-VI-67.
CALVERT: (1)
CARROLL: Marriottsville, 24-VI-69.
GARRETT: Carey Run, 9-VII-82 collected by P.J.Kean.
WASHINGTON: Sideling Hill, 8-VII-67.

Euchlaena serrata (Dru.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 29-VI-65. Loch Raven, 22-VI-70. Parkton, 20-VI-74 collected by W. A.Andersen. Stevenson, 10-VII-71.
CARROLL: Marriottsville, 24-VI-69.

Euchlaena obtusaria (Hbn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, VIII-60, VIII-61, 21-VIII-64, 7-VI & 7 & 14-VIII-65, 27-VIII-67, 29-V & 7 & 10-VI-69, 2,5,6 & 8-VI-70, 27-VIII-71, 2-IX-80, 5-VI & 31-VIII & 5-IX-81, 31-VIII-82, 25-XI-83 & 28-V-85.
CALVERT: (1)

Euchlaena amoenaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 16-VIII-66, 22-V-70, 10-VIII-71, 15-VI-72, 9 & 15-VIII-73, 2-VI-75, 3-VIII-77, 5 & 10-VIII-80, 24,27 & 28-V & 5-VI & 10-VIII-81, 24 & 29-V & 28-VII & 2 & 12-VIII-82, 24-V-83, 20-V & 19-VII-85.
CALVERT: (1)

Euchlaena madusaria (Wlk.)
CARROLL: Reese, 3-VI & 17-VIII-68.

Euchlaena irraria (B. & McD.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 3-VI-70.

Xanthotype sospeta (Dru.)
ALLEGANY: Rocky Gap State Park, 21-VI-82 collected by J.D.Glaser.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-VI-66 & 6-VI-73. Loch Raven, 6-VIII-69.
CECIL: Conowingo, 9-VI-73.
CHARLES: Liverpool Point, 21-VIII-75 collected by W.A.Andersen. Port Tobacco, 6-VIII-83 collected by W.A. Andersen.
PRINCE GEORGES: Fort Washington, 11-VIII-77 (destroyed by vandals) collected by W.A.Andersen.

Xanthotype urticaria Swett
ANNE ARUNDEL: (1)
CALVERT: (1)

Campaea perlata (Gn.)
ALLEGANY: Rocky Gap State Park, 10-VI-82 & 10-VI-83 collected by J.D.Glaser.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 5-VI-66, 15-IX-68, 6-VI-69, 2 & 4-VI & 11 & 18-IX-70, 14-IX-71, 5-VI & 28 & 29-VIII-72, 4 & 6-VI & 7,10 & 13-IX-73, 5-IX-74, 28-V-76, 27-V-80, 22-V & 20-IX-81, 29-V-82, 13-17 & 20-IX-84. Loch Raven, 28-VI-71.
CALVERT: (1)
CARROLL: Reese, 3-VI-68.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

Homochlodes fritillaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 10-V-71 & 2-V-73.

Petrophora subaequaria (Wlk.)
BALTIMORE: Baltimore, Ten Hills, 25-V-69.

Petrophora divisata Hbn.
BALTIMORE: Baltimore, Ten Hills, 30-IV-72.

Cepphis decoloraria (Hlst.)
ANNE ARUNDEL: (1)
CALVERT: (1)

Plagodis fervidaria (H.-S.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 16-V-71, 2-V-72, 28-IV-74, 16,18 & 19-IV-76 & 6-V-85.
CALVERT: (1)

form "arrogaria" Hlst.
BALTIMORE: Baltimore, Ten Hills, 11-VII-73, 4 & 18-VII-80, 8 & 14-VII-82, 8-VII-83 & 24-VII-84.
CARROLL: Reese, 28-VII-72.

Plagodis alcoolaria (Gn.)
ANNE ARUNDEL: Sherwood Forest, 1-VIII-73.
BALTIMORE: Baltimore, Ten Hills, 1-VI-64 & 28-VII-73.

Plagodis phlogosaria purpuraria Pears.
CARROLL: Reese, 28-VII-72.

Probole amicaria (H.-S.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 10-VI-67.

Probole alienaria (H.-S.)
ANNE ARUNDEL: Harwood, 19-IV-76.
BALTIMORE: Baltimore, Ten Hills, 4 & 13-VI-71.
CALVERT: (1)
CARROLL: Reese, 18-V-68.
FREDERICK: Catoctin Mountain Park, 24-VI-83.
GARRETT: Accident, 20-V-71.

form "nyssaria" (Gn.)
BALTIMORE: Baltimore, Ten Hills, 9-VI-72.

Nematocampa limbata (Haw.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 16-VI-83.

Metarranthis hypochraria (H.-S.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 7-VII-64, 10-VI-68, 1 & 11-VI-70, 1 & 9 & 23-VI-71, 24-VI-73, 9-VI-76, 5-VI & 7-VII-80, 12-VI-81 & 18-VI-90.
CALVERT: (1)
CARROLL: Finksburg, 8-VII-73. Marriottsville, 24-VI-69.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

form "broweri" Rupert
BALTIMORE: Baltimore, Ten Hills, 8-VI-65 & 9 & 15-VI-83.

Metarranthis indeclinata (Wlk.)
ANNE ARUNDEL: (1)

Metarranthis homuraria (Grt. & Rob.)
ANNE ARUNDEL: (I)
BALTIMORE: Baltimore, Ten Hills, VIII-60, 7-VIII-70, I4-VII-7I, 11-V & 29-VII-73, 28-V & 4-VIII-75 & 4-VII-84.
CALVERT: (I)

Metarranthis duaria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 21-V-70, I5-VI-81 & 16-VI-83.

Metarranthis angularia B. & McD.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, I4-VI-64, 5-VI-7I, I7-VI-72, 6-VI-80, I5-VI-83, I2-VI-84 & 23-V-85.
CALVERT: (1)
FREDERICK: Catoctin Mountain Park, 24-VI-83.

Metarranthis obfirmaria (Hbn.)
ALLEGANY: Green Ridge State Forest, 26-IV-8I.
ANNE ARUNDEL: (I)
WORCESTER: Unionville, 29-IV-65 collected by W.A.Andersen.

Metanema inatomaria Gn.
BALTIMORE: Baltimore, Ten Hills, 30-VII-72 & 12-V-85.

Selenia kentaria (Grt. & Rob.)
ANNE ARUNDEL: (1)
CALVERT: (I)

Ennomos subsignaria (Hbn.)
BALTIMORE: Baltimore, Ten Hills, 7-VII-68, 28-VI-69, 19 & 30-VI-70, 2,5 & 10-VII-7I, 8,I0,I2,I7,19 & 2I-VII-72, 7 & 14-VII-80, 8 & I8-VII-8I, I2-VII-83, 6-VII-84 & 5 & 9-VII-85.

Ennomos magnaria Gn.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, X-62 & Il-X-84.
CALVERT: (1)

Pero zalissaria (Wlk.)
ANNE ARUNDEL: (I)
CALVERT: (I)

Pero hubneraria (Gn.)
ANNE ARUNDEL: (I)
BALTIMORE: Baltimore, Ten Hills, 8 & I2-V & I2-VIII-64, I0-V & I6-VIII-65, 4-VIII-69, 22-V & 9,I0 & 11-VIII-70, I2-V-72, 24-IV-73, 2-V-77, 27-VII-80 &-20-V-84.
CALVERT: (I)

Pero honestaria (Wlk.)
BALTIMORE: Baltimore, Ten Hills, 5 & 21-VI-66.

Pero morrisonaria (Hy.Edw.)
BALTIMORE: Baltimore, Ten Hills, 5-VIII-82 & 3-VIII-84.

Nepytia semiclusaria (Wlk.)
ST. MARYS: Lexington Park, 26-VI-76.

Caripeta aretaria (Wlk.)
ANNE ARUNDEL: (1)

Lambdina pellucidaria (Grt. & Rob.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 23-V & 8-VI-71, 24-IV & 2,9 & 10-V-73, 5-V-77, 23 & 25-V-81 & 23-IV-85.
CALVERT: (1)

Lambdina fervidaria athasaria (Wlk.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 19-IV-73, 20 & 23-IV-76 & 18-VII-86.
CARROLL: Reese, 20-IV-68 & 6-V-70.

Besma endropiaria (Grt.& Rob.)
ANNE ARUNDEL: (1)

Besma quercivoraria (Gn.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 25-VIII-69, 1-VIII-70, 25-VIII-71, 29-V & 4-VI & 16-VIII-73 & 19-VII-81.
CARROLL: Reese, 8-V & 27-VII-68 & 30-VIII-69.
WASHINGTON: Sideling Hill, 30-IV-77.

Sicya macularia (Harr.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 18-VI-81.

Eusarca confusaria Hbn.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, VI-62, 21-VI-64, 7,8 & 29-VI-65, 31-V & 9-IX-69, 21-VI-71. Catonsville-UMBC, 8-VI-72 & 7-VI-73. Loch Raven, 28-VI-71.
CALVERT: (1)
CARROLL: Marriottsville, 24-VI-69.
MONTGOMERY: Seneca, 4-IX-80 collected by W.A.Andersen.
ST. MARYS: Great Mills, 8-VI-72 collected by W.A.Andersen.

Patalene olyzonaria puber (Grt. & Rob.)
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 27-VI-80. 5 & 17-X-84, 22-V & 10-VII-85.
CALVERT: (1)
CHARLES: Tompkinsville, 7-VIII-71.

Tetracis crocallata Gn.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 6 & 7-VI & 13-VIII-71, 5-VIII-72, 7-VIII-81, 31-VII & 1-VIII-82, 22-V-85 & 30-VII-90.
CALVERT: (1)

Tetracis cachexiata Gn.
ANNE ARUNDEL: (1)

BALTIMORE: Baltimore, Ten Hills, 14-VI-64, 23-V & 5 & 11-VI-70, 3 & 6-VI-71, 17-VI-72, 28-V & 1 & 3-VI-73, 5-VI-81, 13-VI-83 & 4-VI-84.
CALVERT: (1)
CARROLL: Reese, 3-VI-68.
FREDERICK: Catoctin Mountain Park, 24-VI-83.

Eutrapela clemataria (J.E.Sm.)
ALLEGANY: Green Ridge State Forest, 26-IV-81. LaVale, 12-V-83 collected by J.D.Glaser.
ANNE ARUNDEL: (1)
BALTIMORE: Baltimore, Ten Hills, 26-IV-65, 7-VII-66, 12-VII-68, 11-VII-69, 21-V & 13-VII-70, 16 & 18-VII-71, 7-V-72, 18,19 & 23-IV & 2-V-73, 17-IV-74, 24-IV-77, 23-VII-80, 16 & 30-IV & 8 & 18-VII-81, 24-VIII-82 & 22-IV-83.
CALVERT: (1)

Antepione thisoaria (Gn.)
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Ten Hills, 12-VII-69, 24-V & 17-VII & 2-VIII-70, 24-V-71, 29-IV-73, 21-VII-80, 24-V-81, 31-V-82 & 20-VII-85.
CARROLL: Reese, 24-VII-68 & 28-VII-72.

Prochoerodes transversata (Dru.)
ANNE ARUNDEL: Sherwood Forest, 21-VII-64.
BALTIMORE: Baltimore, Ten Hills, 12-VII-68, 11-VII & 8-VIII-70, 15 & 16-VII & 6-XI-71, 5 & 14-X-72, 2-IX-81, 28-X.-83 & ll-X-84.
CALVERT: (1)
CARROLL: Reese, 18-VII-68.
WASHINGTON: Fort Frederick, 30-VII-66 collected by W.A.Andersen.

Maryland Species From Literature
Scopula cacuminaria (Morr.) (2)
Cepphis armataria (H. & S.) (2)
Synchlora frondaria Gn. (3)

Acknowledgements

I want to express my deepest gratitude to Dr. William A. Andersen of Lutherville, Maryland for his help and generosity over many years. His constant willingness to share data from his own collection and his numerous donations of surplus specimens to the Maryland Moth Survey collection are greatly appreciated. A special and long overdue thank you is extended to Dr. Douglas C. Ferguson (National Museum of Natural History, Smithsonian Institution, Washington, D.C.) for his inestimable help in identifying a great many specimens. He was never too tired, at the end of a long day, to cheerfully help untangle numerous knotty identification problems. I also want to thank Mr. John H. Fales of Huntingtown, Maryland, and Mr. John D. Glaser and Mr. Philip J. Kean, both of Baltimore, Maryland, for supplying many useful records. In addition, I would like to thank two anonymous reviewers for their helpful suggestions and corrections. Most were accepted and all were appreciated.

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Plant Species with Potential for Naturalization in Allegany County, Maryland

Simon Dabydeen and Rebecca S. Bennett

Abstract Two introduced species, *Viburnum trilobum* Marsh. and *Lespedeza bicolor* Turcz., have become established within and/or beyond their original introduction sites in Allegany County, Maryland, indicating reproductive success and the potential for wider dispersal and naturalization.

The establishment of introduced plant species is well-documented in many botanical publications, especially floras. In some areas the number of introduced species is so great, or a few species have become so aggressively proliferating and abundant, that the situation is labeled "biological pollution". Introduced plant species are well-known for their negative impacts on the floristic health and composition of invaded areas (Raesly 1993). In Maryland well-known naturalized species include the tree of heaven (*Ailanthus altissima* [Mill.] Swingle), multiflora rose (*Rosa multiflora* Thunb.), chicory (*Cichorium intybus* L.) and Japanese honeysuckle (*Lonicera japonica* Thunb).

Recently, two taxa, *Viburnum trilobum* (highbush cranberry, cranberry tree) and *Lespedeza bicolor* (Japanese clover, bicolor lespedeza), listed as introduced species in Maryland (Brown and Brown 1972, 1984), were observed growing in Allegany County.

According to Don Cober and Ken Oldham (pers. comm.) of the Office of Environmental Design, Maryland State Highway Administration (SHA), these two taxa were introduced with other species along Interstate 68 about fifteen years ago by the SHA in an experimental project aimed at soil erosion control, embankment soil enrichment and roadside beautification. Cober could not locate information concerning the number of plants introduced during the experimental project, but is aware that *Lespedeza bicolor* plants survived and are reproducing. With regard to *V. trilobum*, Oldham stated that the species was planted at certain locations along the median of Interstate 68. He indicated that the plants had canker problems and many did not survive. No *V. trilobum* plants were observed along Interstate 68 in Allegany county, but a population was discovered far away from the probable initial introduction site on the highway.

Viburnum trilobum Marsh. (Caprifoliaceae) is an attractive shrub, up to four meters high, with a distinctive three-lobed leaf. In early July the plant produces numerous white flowers in terminal cymose inflorescences. The fruits are cranberry-like, globose, and bright red in conspicuous clusters. *Viburnum trilobum*, a native North American species, has a natural, mostly northern distribution that includes New Foundland and Nova Scotia to New England, northern Pennsylvania, northern Indiana, northern Illinois, northeast Iowa, the Black Hills in South Dakota, Wyoming, and Washington (Fernald 1970). Brown and Brown (1972) state that this species occurs in the mountain zone both north and south of Maryland but has not been reported in this state. In western Pennsylvania, *V. trilobum* inhabits neutral-alkaline soil wetlands and is believed to be in decline (Anonymous 1993). According to Strausbaugh and Core (1977), *V. trilobum* populations inhabiting the wet woods and stream banks at Canaan Valley in Tucker County, West Virginia, represent the southernmost known locality for this species.

In Allegany County, Maryland, a population of sixteen *V. trilobum* plants (12 with fruits, 4 without fruits) were found growing under an *Acer rubrum-Fraxinus americana-Prunus serotina-Robinia pseudoacacia* canopy in soil covered with a deep layer of plant litter. The site is located in Cumberland, about 80 yards west of the junction of the Greene Street Exit of Interstate 68 East and

Route 220. This group of *V. trilobum* plants, having a zoochoric dissemination strategy, was apparently established from propagules (seeds) dispersed by birds. Dr. Melvin L. Brown (pers. comm.) has observed another population of *V. trilobum* in the forest near Cumberland, and it is likely that other populations exist in Allegany County. It seems unlikely that *V. trilobum* populations in Allegany County represent a disjunct distribution. The plants are too conspicuous not to have been observed during botanical forays of many previous investigators.

Lespedeza bicolor Turcz. (Fabaceae) is a perennial herb up to nine feet tall, with pubescent trifoliate leaves. The plant is extremely floriferous, producing panicles of showy rose-purple flowers and numerous one-seeded indehiscent leguminaceous fruits. It is native to Japan and is found on roadsides and in waste places from Florida to North Carolina (Small 1933). Strausbaugh and Core (1977) state that in West Virginia, *L. bicolor* is much planted along highways and is often well established. The plant has also been introduced into Pennsylvania (Rhoads and Klein 1993), and is naturalized in Anne Arundel (Brown and Brown 1984) and several other counties in Maryland. There is no doubt that this species was introduced for its ability to enrich soil through symbiotic nitrogen fixation.

A population of *Lespedeza bicolor* was found on the very steep embankment of Interstate 68 West, 1.5 miles from the Midlothian Road Exit in Frostburg, apparently the place of initial introduction by SHA (Don Cober, pers. Comm.). The soil at that location is composed predominantly of a mixture of sand and shale. The area occupied by the population is approximately one hundred yards long by fifteen yards wide, and is adjacent to a population of bristly locust (*Robinia hispida* L.) that was also planted as part of same the State Highway Administration experiment (Don Cober pers. comm.). The *L. bicolor* population was relatively large, with flowering and immature plants. Numerical assessments indicated that sixty-five flowering and fourteen nonflowering plants were present. Members of this species were also observed growing sporadically, and generally singly, in waste places at varying distances up to half a mile from the mixed population at the apparent introduction site. This distribution indicates that dispersal of seeds is occurring.

In both *V. trilobum* and *L. bicolor*, the presence of young plants reflects reproductive success. The establishment of new populations away from original planting sites indicates the potential for widespread distribution and naturalization in these species in this area.

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Sea Turtle Strandings in Maryland, 1991 Through 1995

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Introduction

Four species of sea turtles have been reported to occur within the Maryland portion of the Chesapeake Bay or in the ocean and bays along Maryland's Atlantic Coast (Harris 1975). These four, the Atlantic leatherback (*Dermochelys coriacea*), Atlantic Kemp's ridley (*Lepidochelys kempi*), Atlantic green turtle (*Chelonia mydas*), and the Atlantic loggerhead (*Caretta caretta*), are all reliably documented. A fifth species, the Atlantic hawksbill (*Eretmochellys imbricata*), was listed by Harris (1975) as a hypothetical resident based on an old specimen at the Natural History Society of Maryland bearing the notation "occasionally in the Chesapeake Bay and the Maryland Atlantic Coast." However, as noted by Harris (1975) and Groves (1984), there are no bonafide records for *E. Imbricata* in the Maryland area, even though it occasionally occurs along the Atlantic Coast as far north as Massachusetts (Carr 1952).

The first reported Maryland sea turtle seems to have been a large leatherback taken in the Chesapeake Bay in 1811 (Carr 1952). Coincidentally, that specimen represented the first report of this species for North America. Carr (1952) also mentioned a second Chesapeake Bay leatherback taken in 1840 that had been reported by Holbrook (1842). Hardy (1969) discussed three additional published leatherback records from the Maryland portion of the Chesapeake Bay and provided one new record. Ernst and Gilroy (19798) presented evidence that leatherbacks are seasonally common during summer and fall along the Atlantic Coast, but provided no Maryland records. Scarpulla (1989) subsequently provided two sightings of leatherbacks from the Atlantic Ocean off Maryland's coast, and Williams (1995) reported a recent sighting of this species near the bay bridge. The first report of a Kemp's ridley in Maryland was a stranded turtle from Calvert County (Reed 1956), and Hardy (1962) documented five additional Chesapeake Bay specimens. The first Maryland Atlantic green turtle was reported by Robertson (1947), and two additional records were mapped by Harris (1975). McCauley (1945) and Cooper (1947) provided the earliest records of Maryland loggerhead sea turtles, reporting six individuals. Harris (1975), primarily using these published reports for his Maryland distribution survey, mapped records for four leatherbacks, four ridleys, three green turtles and six loggerheads. Additional Maryland sea turtle strandings from 1990 to 1995 recorded by the Maryland Sea Turtle Stranding Program were mentioned by Teas (1992a,1992b, 1992c, 1993, 1994). However, Teas, discussing strandings for the entire northeast, did not include the locations and dates of occurrence for these strandings.

Typically, these records represent waifs or migrating individuals, although there is one record of a loggerhead nesting on a Maryland beach (Graham 1973). Dodd (1988), in a review of the biological data on the Atlantic loggerhead, questioned the identity of this nesting turtle based on Graham's measurements of hatchling carapace length (18.1mm) and width (7.0 mm). He noted that hatchlings around the world are similar in mean carapace length and width, head width, and body mass. Graham's measurements of hatchling carapace lengths and widths were less by 2 and 5 orders of magnitude, respectively, than others reported. Oddly, the body mass reported by Graham indicated normal sized hatchlings (Dodd 1988).

This paper summarizes data from 92 dead sea turtle strandings documented by the efforts of the Maryland Department of Natural Resources (DNR) Marine Mammal and Sea Turtle Stranding Program, from January 1991 through December 1995.

Methods

Marine turtles are protected species under the jurisdiction of two government agencies, the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS), through the

Endangered Species Act. The Sea Turtle Stranding and Salvage Network is administered by the NMFS Southeast Fisheries Center and includes volunteer Stranding Networks along the U.S. Gulf of Mexico and Atlantic coasts in 18 coastal states from Maine through Texas, and portions of the Caribbean. The Maryland Marine Mammal and SeaTurtle Stranding Network is administered jointly by the Maryland DNR and NMFS at the Cooperative Oxford Laboratory (COL) in Oxford, Maryland and the National Aquarium in Baltimore (NAIB). COL personnel respond to beached and stranded carcasses and assist the NAIB with live strandings. The NAIB Marine Animal Rescue Program responds to live strandings and sightings, and in turn assists COL personnel with carcass examination. The network functions through cooperation with many other state, federal, local and non-profit organizations including the Maryland DNR (Fish, Heritage and Wildlife Administration, Natural Resources Police, Forest and Park Service), Maryland Department of Transportation, U.S. National Park Service, U.S. Coast Guard, Patuxent Naval Air Station, USFWS, U.S. Environmental Protection Agency, Calvert Marine Museum, Ocean City (police, beach patrol and public works), and private citizens who live and recreate on and along Maryland waters.

Sea turtle strandings are defined as turtles which wash ashore dead or alive, or are found floating dead or alive but in a weakened condition (Teas 1992a). Only dead sea turtles which stranded along the Maryland coastline, coastal bays and the Chesapeake Bay are included in this report. Sea turtle strandings are reported to the Natural Resources Police 24 hour toll free hotline (1-800-628-9944) and the calls are dispatched to stranding network participants at the Cooperative Oxford Laboratory. A stranding response is organized and executed following established standard operating procedures developed by the COL. Briefly, this entails contacting the individual reporting the stranding and obtaining all available information such as location, accessibility, species, size and carcass condition, coordination of response, data collection, necropsy when possible following protocols as described by Wolke and George (1981), and disposal. Species identification is verified by the Maryland Coordinator or trained volunteers. Longitude and latitude coordinates are obtained using either ADC or nautical maps, or UTM (Universal Topographical Map) or GPS (Global Positioning System) coordinates. All coordinates are plotted using Map Info Software. Curved carapace length (CLC) and width (CCW), carcass condition (freshly dead, moderately decomposed, severely decomposed, dried carcass, skeleton/bones only) and sex using tail length on mature animals are recorded. Turtles are examined for commensal organisms, tags, and signs of injury for determination of probable cause of death. Stomach contents are evaluated for feeding activity, prey composition and ingestion of plastics. Samples for research and educational purposes are also collected and sent to authorized institutions. Frequently, stranded turtles are photographed for identification and documentation.

Results

Species Composition; Annual, Spatial and Temporal distribution

From May 1991 through December 1995, 92 dead stranded sea turtles consisting of three species (Atlantic loggerhead, Atlantic leatherback, Kemp's ridley) were reported from Maryland. Appendix 1 lists selected data on all of the sea turtles stranded along the Atlantic coast that were reported to the stranding network, including the species, date reported, latitude and longitude, length, sex, condition, and probable cause of death. Appendix 2 lists similar information for sea turtles which stranded in the Chesapeake Bay. A summary of the annual stranding totals for individual species and their occurrence along the Atlantic Ocean coastline and the Chesapeake Bay is provided in Table 1. The mean yearly number of strandings over the five year period was 18 turtles. There was an annual increase in the number of reported strandings from 13 in 1991 to 29 in 1995. The exception occurred in 1994 when an number of strandings (13) equivalent to the programs' first year was reported.

Caretta caretta was the most frequently stranded species, making up 91% (84) of the total number of strandings, followed by *D. coriacea* accounting for 8% (7) of all reports. Leatherback strandings occurred in both 1992 and 1995 with 1 and 6 animals reported, respectively. *Lepidochelys kempi* was reported on

one occasion in 1991, although the identification of that individual was uncertain, and comprised 1% (1) of the total annual strandings.

As shown in Table 1, the number of loggerhead strandings along the Atlantic coastline (40) approximated the number from the Chesapeake Bay (44) over the 5 year period. Similarly, leatherback strandings occurred almost equally along the coast (3) and within the bay (4). There were, however, differences in the number of loggerhead strandings from the Atlantic coast and Chesapeake Bay between years. Chesapeake Bay *C. caretta* strandings peaked for the five year period in 1993 (13) and 1995 (17) as compared to the 9 and 6 stranded animals during these years along the Atlantic coastline. Conversely, loggerhead strandings were more numerous along the coastline in 1991, 1992 and 1994, than in the Chesapeake Bay.

Table 1. Summary of stranding records collected by Maryland Sea Turtle Stranding Program from January 1991 through December 1995. Dash (-) indicates that no strandings were reported. Yearly figures are represented as Atlantic Coast(A)/Chesapeake Bay (C).

Species	1991 A/C	1992 A/C	1993 A/C	1994 A/C	1995 A/C	A	C	Total
Caretta caretta	8/4	9/5	9/13	8/5	6/17	40	44	84
Dermochelys coriacea	-	0/1	-	-	3/3	3	4	7
Lepidochelys kempi	-/1?	-	-	-	-	-	1?	1?
Totals	8/5	9/6	9/13	8/5	9/20	43	49	92

Figure 1 shows the location of all sea turtle strandings along the Atlantic coast of Worcester County, Maryland. Although most turtles were found on the beaches of Assateague Island, eight turtles were reported north of the island on the beaches of Ocean City. Strandings were reported much less frequently from the coastal bays, with one loggerhead stranding occurring in Isle of Wight Bay in 1992 and single turtles occurring in Chincoteague Bay in 1994 and 1995. Strandings of sea turtles in the Chesapeake Bay were widespread, occurring from Smith Island in the lower Maryland portion of the Bay northward to Sillery Bay in the Magothy River (Figure 2). The number of loggerhead strandings varied within Bay regions between years but primarily occurred along the Western Shore in Calvert, Saint Mary's and Anne Arundel counties, with an average of 4-5 turtles per year. The loggerhead strandings along the Eastern Shore of the Chesapeake Bay were concentrated in Queen Anne and Talbot counties, with an average of 3 turtles per year. *Dermochelys coriacea* strandings occurred in the Chesapeake Bay along the Eastern Shore adjacent to Queen Anne and Somerset counties.

Caretta caretta strandings occurred from May through December for the 5 year period (Figure 3). The highest numbers of strandings occurred in the month of June and comprised 36% (30) of the total loggerhead strandings for all years combined. The months of July, August, September and October comprised 58% (49) of the total loggerhead strandings with an average of 12 stranded animals per month for all years. Fluctuation in the numbers of loggerhead strandings by month existed for all years with peak strandings occurring in September in 1991, June and August in 1992 and June in 1993 through 1995.

Population Structure

The size frequency distribution of stranded *Caretta caretta* is shown in Figure 4. Curved carapace lengths from these loggerheads ranged from 48.9 to 118.0 cm (N =77, mean = 78.2) and was bimodal in

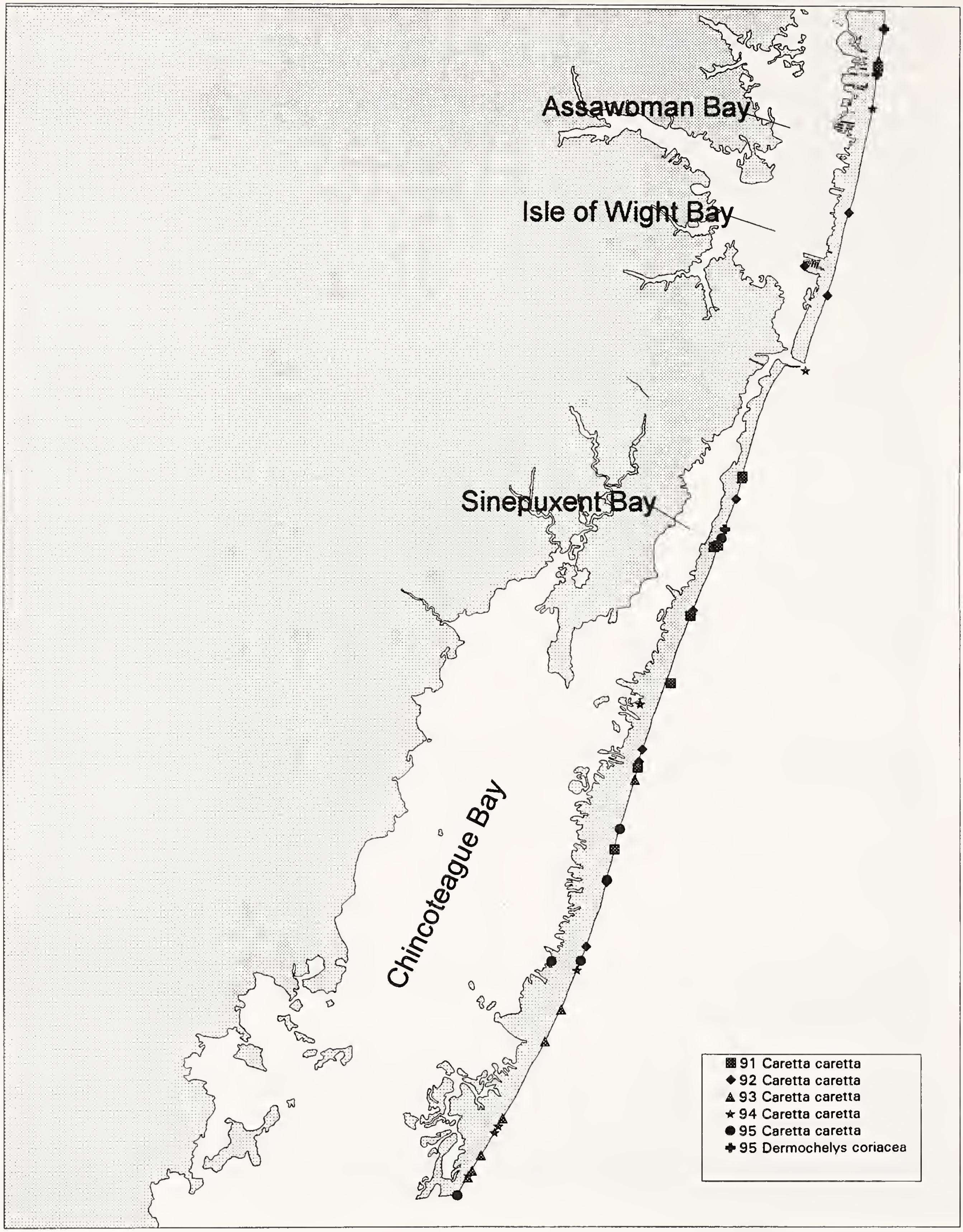

Figure 1. Location of sea turtle strandings along Maryland's Atlantic Coast and coastal bays from January 1991 through December 1995.

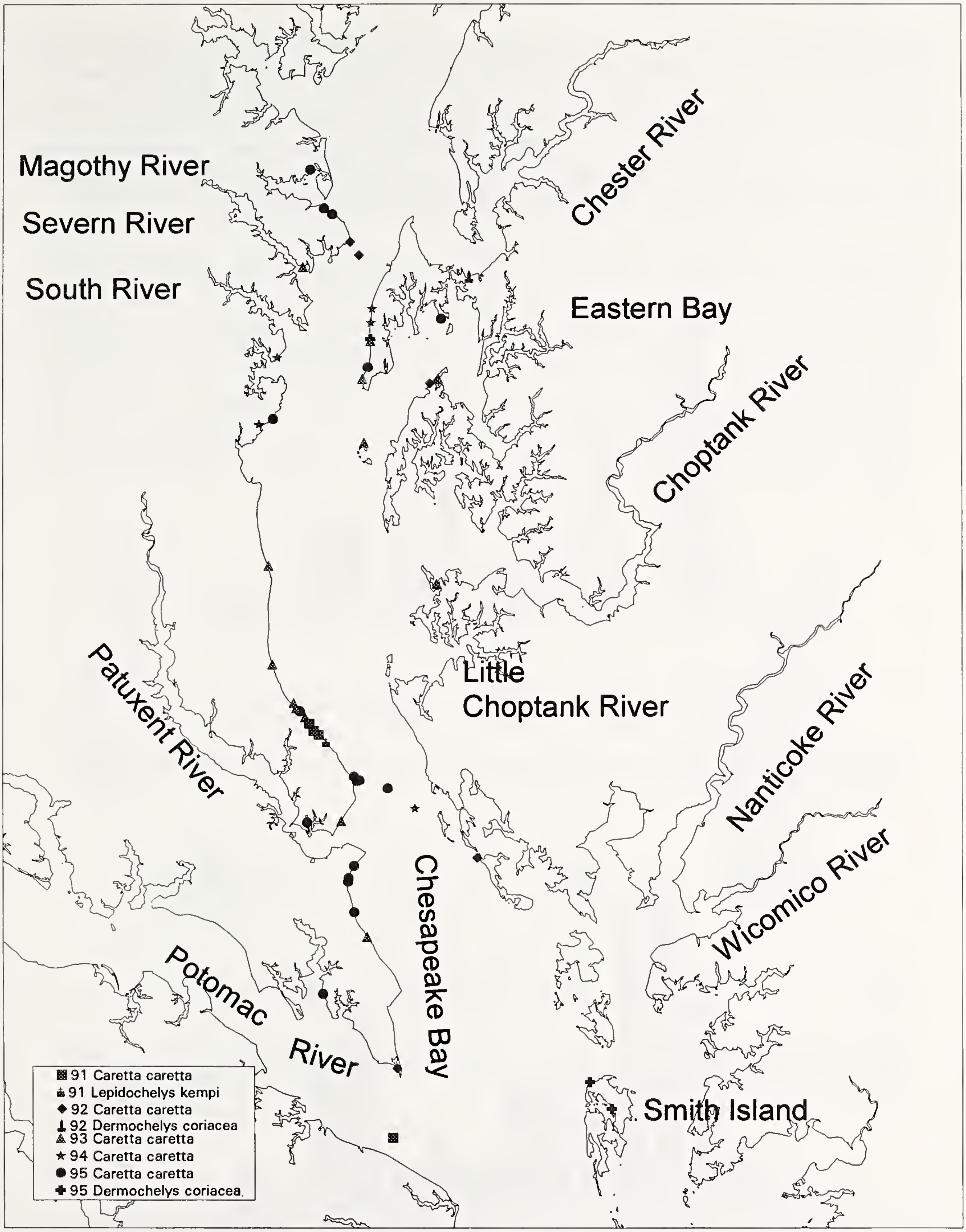

Figure 2. Location of sea turtle strandings in Maryland portion of the Chesapeake Bay from January 1991 through December 1995

distribution. Sixty nine percent (53) of the animals were less than 90 cm, and 64% (34) of these animals ranged from 60 to 70 cm in carapace length. Thirty one percent (24) of the loggerheads were equal to or greater than 90 cm, and 58% (14) of these animals were 105 to 110 cm in carapace length. The seven leatherbacks ranged in size from 139.0 to 199.0 centimeters (mean = 158.1). Of the 25 other leatherbacks tabulated by Ernst and Gilroy from this region (Maryland, Virginia, Delaware, New Jersey), the ten individuals for which carapace length measurements were available were also large individuals, ranging from 136 to 180 cm (mean = 138.8) in length. The possible Kemp's ridley was 55.9 centimeters in length.

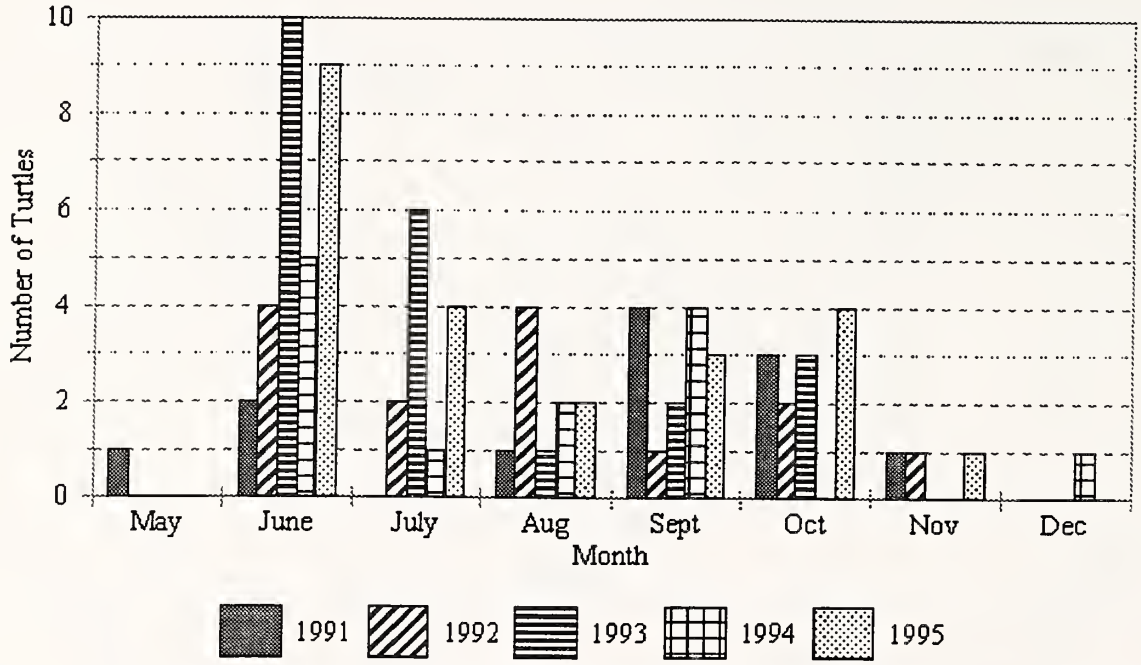

Figure 3. Monthly distribution of Atlantic loggerhead sea turtle, *Caretta caretta*, strandings recorded in Maryland waters from January 1991 through December 1995.

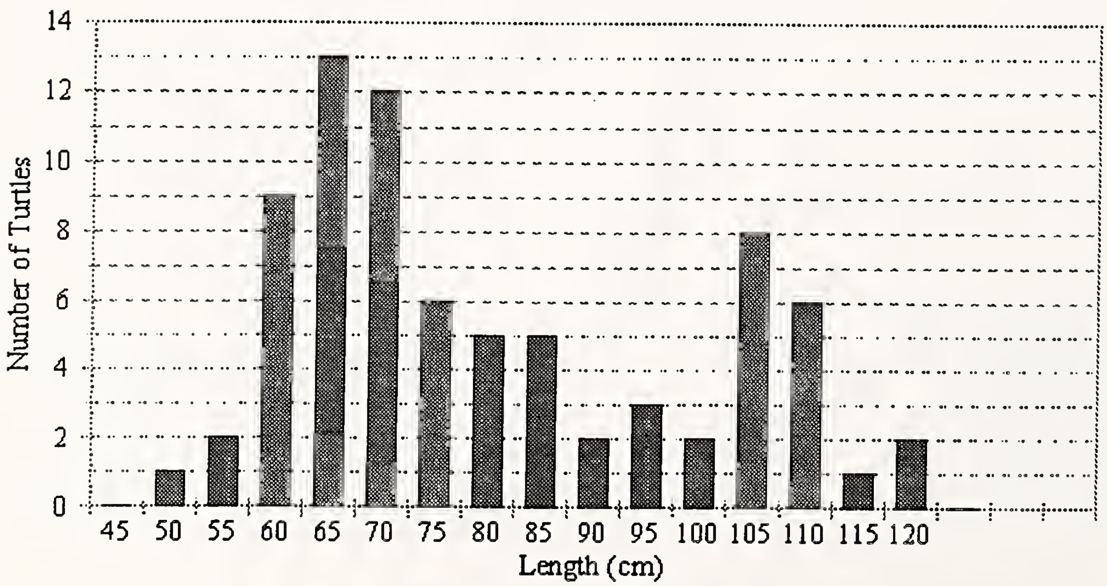

Figure 4. Distribution of carapace lengths (centimeters) for loggerhead sea turtle, *Caretta caretta*, strandings in Maryland waters from January 1991 through December 1995.

The sex of 79% (66) of the loggerhead turtles was undetermined. Of those approximately 90 cm or greater where sex could be determined based on tail length, 12 were females and 6 were males. The sex of stranded leatherbacks was not determined.

Condition of Stranded Turtles and Probable Cause of Death

Of the 84 dead stranded loggerhead turtles, 40% (34) were recorded as severely decomposed, 34% (29) as moderately decomposed, 18% (15) as freshly dead and 7% (6) as skeletonized or bones only. Of the 7 dead stranded leatherback turtles, 4 were severely decomposed, 2 were moderately decomposed and 1 was relatively fresh. The probable cause of death was undetermined in 77% (65) of all loggerhead sea turtles examined and 43% (3) of all leatherback turtles examined. The probable cause of death was determined in 25% (23) of the total number of the stranded animals, and was typically associated with human interaction (Figure 5). Boat related injuries from prop impact or collision were ascertained to be the cause of death in 13% (11) of the loggerhead and 43% (3) of the leatherback strandings from both the Atlantic coastline and Chesapeake Bay for all five years. Seven loggerhead strandings (8%) and one leatherback stranding (14%) were believed to have been the result of fishery interactions. Necropsies of these animals suggested drowning or suffocation. Many of these turtles had freshly eaten prey, primarily fish and crustaceans, in their stomachs. One loggerhead died as a result of dredging activity.

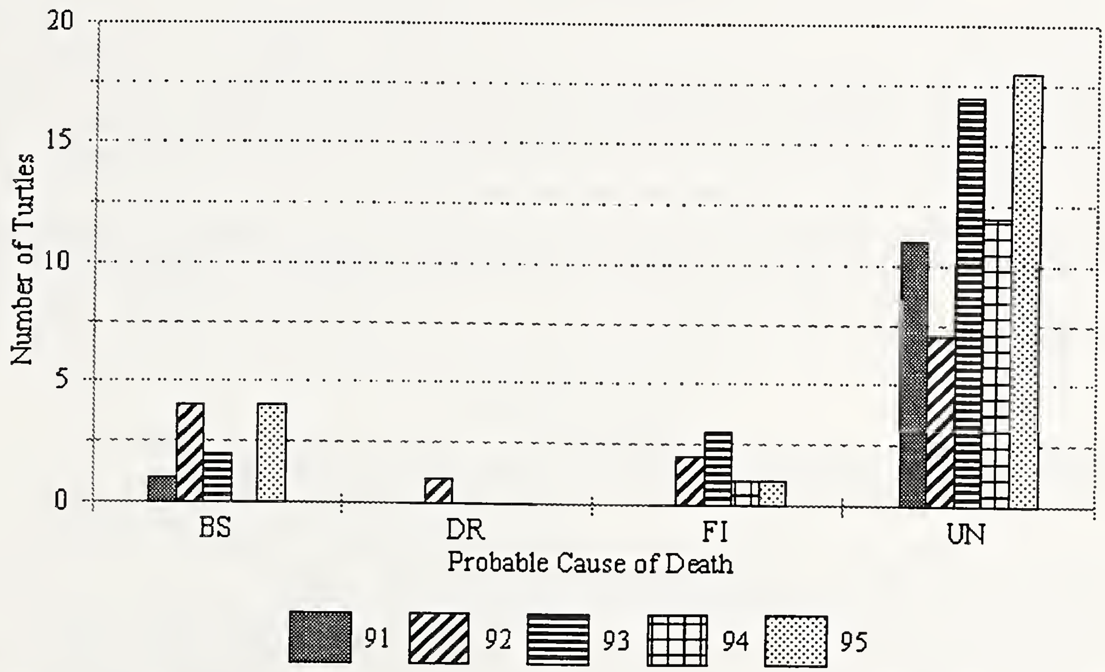

Figure 5. Probable cause of death of Atlantic loggerhead sea turtles, *Caretta caretta*, stranded in Maryland waters from January 1991 through December 1995. BS= boat strike, DR= dredging, FI= fisheries interaction, UN= unknown.

Discussion

This five year summary of stranded sea turtles in Maryland demonstrates that these reptiles occur in Maryland waters far more abundantly than previously reported. These data also verify the effectiveness of the Maryland Sea Turtle Stranding Program, which in five years more than quadrupled the number of Maryland records gathered over the previous fifty years. While the numbers of reports varied from a low of 13 in 1991 and 1994 to a high of 29 in 1995, we cannot ascertain if these numbers reflect fluctuations in the

number of sea turtles entering Maryland waters, variations in effort between and/or within years, or increased public awareness and more effective reporting mechanisms. Stranding numbers indicate a summer through early fall seasonal occurrence and distribution in Maryland waters. The size distribution of stranded loggerhead sea turtles suggests the occurrence of both subadult and adult populations in Maryland waters, based on the definition of size categories given for loggerhead populations by Lutcavage and Musick (1985) and Dodd (1988). Juvenile turtles < 45 cm were not represented. All of the leatherback sea turtles were within the size range expected of adult turtles. Although the cause of death was not determinable for most specimens due to advanced decomposition, human interactions were documented for 35% (17) of those turtles found either freshly dead or moderately decomposed. This indicates that reporting and response time is critical to assessing cause of death. Boat collisions, followed by fisheries interactions, were the primary probable causes of death, with the latter being difficult to assess accurately. Lutcavage and Musick (1985) in an assessment of dead stranded sea turtles in the Virginia portion of the Chesapeake Bay indicated that entanglement and drowning or suffocation in pound net hedging is a major factor when cause of death is apparent. They cited net location, mesh size, tidal current regime and the physical condition of the turtle as contributing factors affecting turtle entanglement. The regular occurrence and mortality of sea turtles in Maryland waters suggest the need for a directed research effort and the development of a conservation management plan for these endangered and threatened animals.

Acknowledgments

Many thanks are due to Dr. Cindy Driscoll for the initiation, establishment and continued support of the stranding program, to Dr. Eric May for the use of equipment, and to Aquatic Animal Health Program personnel for stranding responses. We also thank the National Aquarium in Baltimore for permitting the Maryland Department of Natural Resources Stranding Program to operate under their National Marine Fisheries Service Letter of Authorization to respond to stranded animals. We thank Kelly Greenhawk at the Cooperative Oxford Laboratory, who instructed and assisted us in the generation of the figures. We are grateful to Mr. Jack Kumer and his staff at Assateague National Seashore who provided invaluable reporting, participation and response efforts for many of the stranded coastal sea turtles. Although too numerous to mention individually, special thanks are also due to all of the other persons who reported strandings or assisted in recovery operations.

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Appendix A. Selected information on sea turtles that stranded along Maryland's Atlantic Coast and coastal bays from January 1991 through December 1995.

	Date	Latitude[a]	Longitude[a]	Length (cm)	Sex[b]	Condition[c]	Cause[d]
Caretta caretta	09/09/91	381044	750939	56.0	U	SK	UN
	09/17/91	380900	751017	112.0	U	SK	UN
	09/21/91	382551	750308	84.2	F	AD	UN
	09/25/91	381701	750649	104.0	F	MD	UN
	10/01/91	381529	750735	83.0	F	MD	UN
	10/06/91	381233	750845	103.0	F	MD	UN
	10/27/91	381531	750728	93.0	M	MD	UN
	11/04/91	381400	750813	101.0	F	AD	UN
Caretta caretta	06/26/92	380656	751103	81.5	U	MD	FI
	06/29/92	381407	750809	N/T	U	AD	BS
	07/03/92	380818	751030	70.0	U	AD	DR
	07/28/92	381108	750931	91.0	U	MD	FI
	08/09/92	382133	750508	65.0	U	MD	BS
	08/15/92	382055	750431	98.0	F	AD	UN
	08/15/92	382241	750356	90.0	U	AD	UN
	10/10/92	381632	750659	104.0	F	AD	UN
	10/10/92	381052	750937	110.0	M	AD	UN
Caretta caretta	06/17/93	381659	750650	67.0	U	MD	UN
	07/06/93	381029	750944	105.0	F	RF	BS
	07/25/93	380229	751354	118.0	M	AD	UN
	07/30/93	380200	751416	106.0	F	AD	UN
	09/02/93	380535	751144	107.0	F	RF	BS
	09/15/93	380209	751409	108.0	M	MD	UN
	10/12/93	380316	751319	107.0	F	AD	UN
	10/16/93	380454	751210	68.5	U	MD	UN
	10/27/93	382559	750307	64.5	U	AD	UN
Caretta caretta	06/22/94	380258	751332	74.0	U	AD	UN
	07/06/94	381917	750507	104.0	M	AD	UN
	08/12/94	380306	751326	67.0	U	MD	UN
	08/23/94	382457	750317	69.0	U	MD	UN
	09/22/94	380202	751415	88.5	U	AD	UN
	09/22/94	380626	751118	82.0	U	AD	UN
	09/26/94	381401	750812	109.0	M	RF	UN
	12/03/94	381206	750935	64.5	U	MD	UN
Caretta caretta	06/30/95	380137	751433	101.5	U	MD	BS
	07/05/95	380638	751112	71.5	U	AD	UN
	07/07/95	381540	750723	77.0	U	AD	UN
	09/20/95	380926	751008	102.0	U	AD	UN
	09/25/95	380821	751029	62.5	U	MD	UN
	11/30/95	380637	751200	61.0	U	RF	UN
Dermochelys coriacea	06/27/95	382640	750258	139.0	U	AD	BS
	09/12/95	382541	750310	151.0	U	AD	UN
	09/26/95	381552	750717	199.0	U	AD	UN

[a] Degrees, minutes, seconds
[b] F = Female, M = Male, U = Unknown
[c] RF = Relatively fresh, MD = Moderately decomposed, AD = Advanced decomposition, SK = Skeletonized
[d] FI = Fisheries interaction, BS = Boat strike, HI = Human interaction, UN = Unknown

Appendix B. Selected information on stranded sea turtles from the Maryland portion of the Chesapeake Bay from January 1991 through December 1995.

	Date	Latitude[a]	Longitude[a]	Length (cm)	Sex[b]	Condition[c]	Cause[d]
Caretta caretta	05/29/91	375800	762000	73.7	U	RF	UN
	06/19/91	382700	762800	N/T	U	AD	BS
	06/19/91	382700	762800	58.4	U	RF	UN
	08/08/91	382700	762800	91.4	U	MD	UN
Lepidochelys kempi	05/22/91	382700	762800	55.9	U	MD	UN
Caretta caretta	06/12/92	380248	761936	N/T	U	AD	UN
	06/14/92	381730	761230	65.0	U	AD	UN
	08/01/92	385942	762256	73.0	U	RF	BS
	09/07/92	390036	762344	59.0	U	RF	BS
	11/27/92	385041	761639	N/T	U	SK	UN
Dermochelys coriacea	09/12/92	385811	761309	145.5	U	AD	BS
Caretta caretta	06/02/93	382758	762832	56.0	U	RF	FI
	06/03/93	382736	762800	53.3	U	AD	UN
	06/05/93	382820	762845	62.2	U	RF	UN
	06/15/93	385100	761555	N/T	U	SK	UN
	06/16/93	385853	762756	70.0	U	MD	FI
	06/22/93	383638	761605	76.0	U	AD	UN
	06/22/93	385059	762237	64.0	U	AD	FI
	06/28/93	384630	762230	64.0	U	SK	UN
	06/30/93	383753	763059	N/T	U	AD	UN
	07/11/93	385341	762156	60.0	U	AD	UN
	07/15/93	382005	762432	66.0	U	AD	UN
	07/23/93	383101	763037	58.5	U	SK	UN
	08/01/93	381200	762215	69.5	U	RF	UN
Caretta caretta	06/03/94	385500	762153	53.0	U	RF	FI
	06/12/94	384748	763148	80.0	U	MD	UN
	06/18/94	382100	761759	67.0	U	AD	UN
	06/20/94	385232	763010	61.0	U	RF	UN
	09/14/94	385559	762145	N/T	U	RF	UN
Caretta caretta	06/02/95	381656	762324	69.9	U	AD	UN
	06/09/95	385150	762208	74.5	U	MD	UN
	06/12/95	382312	762324	76.0	U	AD	UN
	06/13/95	390257	762605	60.0	U	MD	UN
	06/18/95	382223	762024	68.6	U	AD	UN
	06/19/95	385514	761539	62.5	U	MD	UN
	06/20/95	380759	762610	83.2	U	MD	UN
	06/28/95	381343	762323	116.0	F	MD	UN
	07/05/95	382255	762304	63.0	U	MD	BS
	07/06/95	381606	762353	60.3	U	AD	UN
	08/14/95	390542	762717	60.0	U	MD	UN
	08/18/95	390231	762518	57.0	U	MD	UN
	09/25/95	382746	762811	48.9	U	MD	BS
	10/01/95	381551	762355	66.0	U	AD	UN
	10/03/95	381959	762732	71.8	U	RF	BS
	10/14/95	382253	762307	99.8	U	MD	FI
	10/22/95	384810	763034	75.5	U	MD	UN
Dermochelys coriacea	06/22/95	380001	760037	147.0	U	MD	UN
	07/16/95	385350	762156	171.5	U	MD	BS
	07/25/95	380153	760233	154.0	U	RF	FI

[a] Degrees, minutes, seconds
[b] F = Female, M = Male, U = Unknown
[c] RF = Relatively fresh, MD = Moderately decomposed, AD = Advanced decomposition, SK = Skeletonized
[d] FI = Fisheries interaction, BS = Boat strike, HI = Human interaction, UN = Unknown

Incidence of *Physaloptera turgida* Rudolphi (1819) in the Virginia Opossum (*Didelphis virginiana* Kerr 1792)

Karen Ackerson Keller, Amy L. Harman, and Dan M. Harman

Abstract. Fifty-one opossums from the two westernmost counties of Maryland were examined for the parasitic nematode *Physaloptera turgida* Rudolphi (1819). Thirty-seven opossums (73%) yielded a total of 873 *P. turgida.* Most *P. turgida* (87%) were collected from the opossum stomach, with 10% from the esophagus and 3% from the small intestine. Parasite abundance per host was 17.1, with a range of 1 to 156. Opossum age and weight were correlated with prevalence and abundance of *P. turgida.* Analysis of stomach contents indicated that grasses were the most common foods, followed by earthworms and insects.

Introduction

The parasitic nematode, *Physaloptera turgida* Rudolphi (1819), is one of the most prevalent nematode parasites of the Virginia opossum, *Didelphis virginiana* Kerr 1792. It has been reported from 13 of the eastern United States, extending from the Atlantic coast westward as far as Kansas and Texas (Gray 1981). In an Illinois study, Alden (1995) found *P. turgida* to be decidedly more prevalent than other opossum parasites. Prevalence of *P. turgida* among opossums in some localities may be high. In several studies, 100 percent of animals examined were infected (Alden 1995 in Illinois, Stewart and Dean 1971 in Georgia, Sandidge 1953 in Kansas, Hamilton 1951 in New York, Hill 1939 in Oklahoma). Between 90 and 95 percent infection rates were observed by Blumenthal and Kirkland (1976) in Pennsylvania, Feldman et al. (1972) in Virginia, and Leigh (1940) in Illinois. Several authors reported infection rates between 72 and 90 percent (Gray and Anderson 1982 in Florida, Miller and Harkema 1970 in North Carolina, and Sherwood et al. 1969 in Virginia).

The life cycle of *P. turgida* was described by Zago Filho (1959). Nematodes live in the gut, primarily the stomach, of the definitive host, the opossum. Nematodes reach sexual maturity in the stomach, mate and release eggs. Embryonated eggs pass through the host gut and are released with feces. Upon ingestion by a suitable intermediate host, usually an arthropod (Anderson 1988), the larvae hatch. Encystment occurs in the intermediate host gut wall, where development proceeds to the infective third stage. Blumenthal and Kirkland (1976) found most *P. turgida* in the stomachs of infected opossums; however, many were found in the small intestine, and some in the esophagus, oral cavity and trachea. Others reported *P. turgida* only in the stomach (Stoner 1945, Nettles et al. 1975, Skrjabin 1968, Anonymous 1986) and more specifically, attached to the stomach wall (Sherwood et al. 1969, Gray 1981, Anderson 1988). Gray and Anderson (1982) determined that *P. turgida* attached to the greater curvature of the gastric corpus. Nematode induced ulcers less than 1 mm in diameter resulted from larval attachment; ulcers from 2 to 3 mm were due to adults; and ulcers from 6 to 15 mm were due to large adults. Miller and Harkema (1970) found that *P. turgida* actually penetrated the stomach wall. Reportedly, *P. turgida* may noticeably affect the health of the host. Severe effects were reported by Potkay (1970), although other reports indicated only occasional or light symptoms and few deaths (Krupp 1962, Sherwood et al.1969, Feldman et al. 1972).

Alicata (1937) found experimentally that *P. turgida* will develop in the German cockroach *Blatella germanica* L. Gray, and Anderson (1983) also determined that the field cricket (*Acheta pennsylvanicus* Burmeister) is a suitable host for *P. turgida* because most larvae reach the third stage in this host. The intermediate host is consumed by the opossum and encysted larvae are then released and molt through fourth stage adults. Paratenesis is also possible and is probably important in *P. turgida* transmission to opossums (Anderson 1988). Although no development occurs in the paratenic hosts, which may include frogs, snakes, and small mammals, it may be advantageous to the parasite to be carried

by a larger animal than the intermediate host, if that animal is commonly eaten by the opossum (Maggenti 1981). When the definitive host consumes the paratenic host, nematodes continue development to sexual maturity. Paratenesis of *Physaloptera* spp. is unusual because larvae in paratenic hosts occupy the same site as in the definitive host (Anderson 1988).

A few studies have attempted to relate prevalence/abundance of *P. turgida* in opossums to environmental factors. In one attempt, Blumenthal and Kirkland (1976) analyzed prevalence/abundance in relation to habitat, host sex, and seasonal variations. Their data indicated no significant differences in regard to these factors. However, abundance was correlated with host age. Also, Cawthorn and Anderson (1975), Pence and Mienzer (1979), and Gray (1981) determined that prevalence of *Physaloptera* spp. is frequently greater in older host mammals, i. e., skunks, coyotes and opossums.

A number of investigations have provided information on opossum diet (Blumenthal and Kirkland 1976, Hamilton 1951, Fitch 1953, Sandidge 1953, Hamilton 1951, Stoner 1945). Predominant items found in gut contents were earthworms, insects and other invertebrates, plant foliage, fruit, and seeds. Seasonal differences in diet were noted, with insects being prominent during warm months and mammalian tissue in late fall and winter.

Goals of this investigation were threefold: 1) to extend the data base on prevalence and abundance of *P. turgida* in the Virginia opossum by presenting information from Maryland, from which there are no previous reports, 2) to test abundance and prevalence against several collection site factors which have received little attention in past literature and 3) to analyze stomach contents to assess host food groups.

Materials and Methods

Opossums were collected and recorded by date and location in Allegany and Garrett Counties, Maryland. These two counties were in different physiographic regions; the first in the Ridge and Valley Province and the second in the Allegheny Plateau.

Most of the opossums collected were road-killed, and had been dead for an undetermined time. Some of these were dissected immediately, whereas others were frozen for later examination. A few specimens were live-trapped (1) or live-trapped, euthanized with chloroform, and (a) immediately dissected or (b) frozen for later dissection.

After tying both ends, the opossum stomach was cut lengthwise and contents flushed with water. Diluted contents were then examined in Petri dishes for nematodes and food items. Nematodes were removed and placed in physiological saline, with forcep detachment of those clinging to the stomach wall. Presence of plant materials (grasses, seeds, leaves, etc.) and animal remains (earthworms, insects, mammals, egg shells, birds, snails, fish and hair) was recorded.

Numbers, location (esophagus, stomach and small intestine) and position (attached to mucosa or in organ lumen) of *P. turgida* were recorded for each opossum. Live nematodes were fixed in hot 70 % alcohol and stored in glycerin-formaldehyde or glycerin-alcohol mixtures. Length, width, age, sex and stage (male, female or larva) were determined for each nematode. Females were distinguished from males based upon length, which is approximately 1.5 times that of males (Gray and Anderson 1982). Males were also identified by the presence of a bursa. Nematodes smaller than adult males, with no bursa, were identified as larvae.

Prior to dissection, opossums were weighed and dental formulae recorded. Numbers of incisors, canines, premolars and molars were recorded for upper and lower jaws. Age was determined using dental

formulae, in combination of the methods of Petrides (1949), and Blumenthal and Kirkland (1976), who grouped animals as either juvenile, subadult or adult. Opossums are known to live up to 3 years in the wild (Merritt 1987). For this study opossums four months and younger were considered juveniles; those 5 to 11 months, subadults; and those older than 11 months, adults. Because there was overlap, weights were also considered in aging. Animals lacking data from dental formulae were aged using weight categories derived from previously aged animals.

At collection, opossums were designated either residential or rural, in reference to their proximity to human concentrations. For purposes herein, "residential" was defined as being within 1.6 km of urban or suburban human habitation, whereas "non-residential" or "rural" was considered more than 1.6 km from such habitation. The distance, 1.6 km, was estimated as a maximum radius beyond which daily contact was unlikely. Residential sites were usually adjacent to lots, yards or buildings, whereas rural sites of this study were all adjacent to woodlands.

A 5-way factorial ANOVA was attempted to determine relationships between the dependent variables, prevalence and abundance, and the independent variables -- host age, host sex, host weight, county, proximity to human habitation and season. Student's T and Chi-square tests were used to test for relationships between prevalence/abundance and the independent variables separately.

Results

A total of 873 *P. turgida* was taken from 72.5% of the opossums (37 of 51). Overall abundance of *P. turgida* was 17.1, with a range of 1 to 156 nematodes. As shown in Table 1, 75% of the opossums (6 of 8) from Garrett County were infected. Abundance was 7.3 with a range 1 to 27. Seventy-two percent of opossums (31 of 43) from Allegany County were infected. Abundance was 18.5 with a range 1 to 156.

Factorial ANOVA inferred significant relationships only between parasite abundance and the independent variables age and weight ($P<0.05$). Additional one-way factorial ANOVA, T-tests, and Chi-square were used to test for differences against the independent variables separately, as shown in Table 1. These additional tests revealed no further significant relationships.

To further describe the findings, combinations of independent variables which were believed to be logically associated with each other were tabulated. Prevalence and abundance of *P. turgida* in relation to human proximity and county are shown in Table 2. Although overall abundance in Allegany was more than twice that of Garrett County (18.5 *P. turgida* versus 7.3, respectively), the two were not statistically different. As 6 of 8 Garrett County collection sites were rural, no comparison of rural versus residential sites was possible for Garrett County. In contrast, 38 of 43 sites (88%) in Allegany County were residential. Combined prevalence of *P. turgida* was similar for residential and rural collection sites (Table 2). Abundance was numerically (though not statistically) greater for residential than rural sites (19.8 versus 8.3, respectively).

A second group of associated independent variables was opossum age, weight and sex. These were also tabulated against the dependent variables, parasite prevalence and abundance, as shown in Table 3. Prevalence and abundance increased among age groups, i.e., juvenile, subadult, adult, as did opossum weight. However, among adults, males were heavier than females. Five of 51 opossums collected were juveniles, 21 were subadults, and 25 were adults. Two juveniles had nematodes (range 2 to 3); whereas 14 subadults had nematodes (5.9 abundance per host, range 1 to 26); and twenty-one adults had nematodes (29.8 abundance per host, range 1 to 156).

Table 1. Tests for differences in Physaloptera turgida prevalence and abundance in opossums by study variables, showing statistical inferences.

Study Variables	No. of opossums	Prevalence: % infected	Prevalence: Chi-sq.	Abundance: P. turgida per host	Abundance: Statistics
Host Age			*P = 0.00		*ANOVA; F = 6.21 P = 0.004
adults	25	84		29.8	
subadults	21	67		8.7	
juveniles	5	40		1.0	
Host Weight			*P = 0.00		* t-test; t = -3.03 P = 0.005
below mean	24	63		6.0	
above mean	27	81		27.9	
Host Sex			P = 0.31		t-test; t = 0.90 P = 0.370
females	23	78		21.6	
males	28	68		13.5	
County			P = 0.42		t-test; t = 1.84 P = 0.08
Garrett - Alleg. Plateau	6	75		7.3	
Allegany - Ridge & Valley	43	72		18.5	
Human Proximity			P = 0.48		t-test; t = 2.00 P = 0.051
residential	39	72		19.8	
rural	12	75		8.3	
Season of Collection			P = 0.11		ANOVA; F = 7.43 P = 0.077
spring	7	86		11.0	
summer	11	91		14.6	
fall	30	60		15.7	
winter	3	100		57.7	

Table 2. Prevalence (Prev) and abundance (Abund) of Physaloptera turgida in the Virginia opossum by county and human residence factor.

	Counties of collection:								
	Allegany			Garrett			Combined		
Human residence	No. opos-sums	Prev (%)	Abund #/host	No. opos-sums	Prev (%)	Abund #/host	No. opos-sums	Prev (%)	Abund #/host
Residential	38	74	20.4	1	0	0.0	39	72	19.8
Rural	5	60	4.4	7	86	11.0	12	75	8.3
Combined	43	72	18.5	8	75	7.3	51	73	17.1

Table 3. Prevalence and abundance of Physaloptera turgida by opossum age class, weight and sex.

Opossum age and sex	No. opos. total	Mean weight (g)	Phyaloptera turgida Abundance No.	Ave/ host	Preva-lence (%)
Adult					
male	12	2361	289	24.1	83
female	13	1548	455	35.0	85
combined	25	1954	744	29.8	84
Subadult					
male	14	1268	85	6.1	57
female	7	1262	39	5.6	86
combined	21	1265	124	5.9	67
Juvenile					
male	2	678	3	1.5	50
female	3	783	2	0.7	33
combined	5	730	5	1.0	40

Twenty-three opossums were females, of which 18 (78%) were infected with nematodes. Abundance of parasites per female host was 21.5, with a range of 1 to 156. Nineteen of 28 males (68%) were infected. Parasite abundance per male was 13.5, with a range of 1 to 77.

Parasite abundance per host was also compared against opossum weight. Average weight for all animals was 1609.2 g. Twenty-four of 51 opossums weighed below mean weight, whereas 27 were above. Fifteen opossums below mean weight were infected, with an abundance of 6.0 nematodes per host (range 1 to 36), whereas 22 opossums above mean weight were infected with an abundance of 27.0 nematodes per host (range 1 to 156). Since age and weight in opossums were related, it was necessary to compare abundance among weight and age classes, as shown in Figure 1. In each comparison, except for the top weight class, *P. turgida* abundance per host increased with host weight.

Parasite abundance and prevalence values are shown against season of collection in Table 4. Abundance of *P. turgida* averaged 11.0, 14.6, and 15.7 for spring, summer, and fall respectively. Abundance among the three opossums collected in winter (57.7) appeared high relative to the other seasons, but low opossum numbers (3) precluded statistical significance. Prevalence (%) of opossums infected varied from 60 to 86 to 91 for fall, spring and summer, respectively.

Table 4. Abundance and prevalence of Physaloptera turgida in Maryland opossums by season of year.

Season of year	Number of opossums	Physaloptera turgida Abundance per host Ave.	S. D.>	Prevalence (%)
Summer	11	14.6	16.5	91
Fall	30	15.7	31.7	60
Winter	3	57.7	23.9	100
Spring	7	11.0	9.4	86

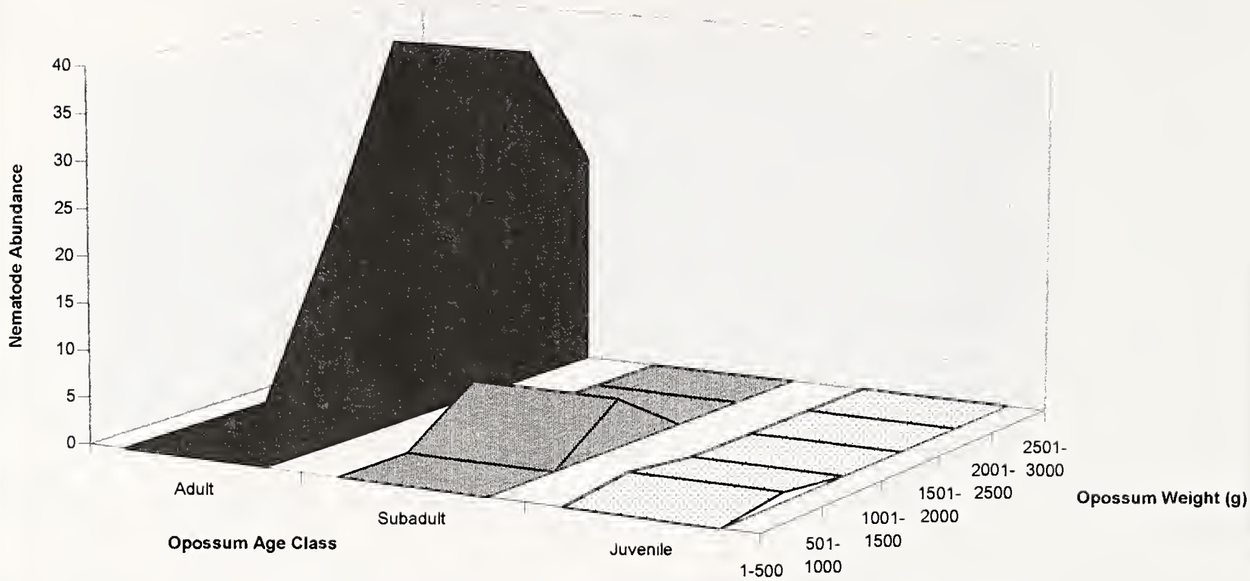

Figure 1. Abundance per opossum of Physaloptera turgida by weight and by age class.

Eleven categories of stomach contents were identified, as follows: grasses in 44 animals (86%); hair in thirty-one (61%); earthworms in thirty (59%); insects in twenty-two (43%); fruit/seeds in twenty-two (43%); leaves in nineteen (37%); mammal parts in 12 (24%); avian egg shells in 7 (14%); avian parts in 5 (10%); snails in 5 (10%); and fish in 1 (2%). Although hair is a primary mammalian characteristic, a separate category for hair was included when no other mammalian parts were found. All contents other than hair were concluded to be food items of the opossum. Predominant food categories by season per collected opossum are shown in Table 5. Grasses were most common, followed by earthworms, in all seasons except winter.

Most *P. turgida* found in this study occurred in the opossum stomach. Of 873 nematodes found, 757 (86.7%) were in the stomach, 90 (10.3%) in the esophagus, and 26 (3%) in the intestine. Incidence of nematodes in different portions of the gut is shown in Table 6. Of the 37 opossums infected, 29 were road-kills and were dissected immediately or frozen. Among these, nematodes occurred singly or in combinations of organs as follows: esophagus, 2; stomach, 18; esophagus and stomach, 8; and in all three (esophagus, stomach, and small intestine), one opossum. The opossum with the highest number of parasites per host (156) was the sole animal with any intestinal nematodes. Distribution of *P. turgida* in this opossum was 29 in the esophagus, 101 in the stomach, and 26 in the small intestine. All eight of the infected opossums trapped and immediately dissected or frozen, had nematodes only in the stomach.

Discussion

Results of this study indicated only moderate prevalence of *P. turgida* (72.5%) relative to several studies by other authors, who reported 90 to 100 percent prevalence. Parasite abundance per opossum (17.1) was similar to that of past studies (Leigh 1940, Blumenthal and Kirkland 1976, Gray 1981). Possibly a portion of the Maryland opossum population was not exposed to *P. turgida* because of low population levels of opossums and/or alternate and paratenic hosts.

Table 5. Food preference by season as determined from stomach contents.

Season	No. opos. examined	Food item categories found in opossum stomachs from greatest (left) to least (right) frequency						
Spring	7	grass	earth-worm	insect	egg shell	(mam-mal/ bird/ snail)		
Summer	11	grass	(earth-worm/ insect)	fruit	(leaf/ mam-mal/ egg shell/ bird/ snail)			
Fall	30	grass	(earth-worm/ leaf)	insect	mam-mal	(egg shell/ bird)	snail	fish
Winter	3	mam-mal	(grass/ fruit/ leaf/ snail)					

Table 6. Nematode location in gut for 51 opossums sampled in western Maryland.

Portion of Gut	No. of Opos.	Number of Physaloptera turgida: Total	% of Total	Ave.	Range	No. of opossums with Physaloptera turgida *: Road-killed A	Road-killed B	Trapped A	Trapped B
Stomach	35	757	86.7	21.6	1-103		18	5	3
Esophagus	11	90	10.3	8.2	1-35		2		
Small intestine	1	26	2.9						
Stomach and esophagus						1	7		
Stomach, esophagus and small intestine	1						1		

*A= Dissected immediately
B= Frozen then dissected

The two counties, Allegany and Garrett, were considered distinct enough to warrant comparison, primarily in respect to elevation, temperature, and rainfall. Sex of host was considered important, as various factors such as physiology and diet might vary between sexes and influence parasite success. Likewise, it was hypothesized, season of year could influence diet, host physiology and other features. Also tested was the hypothesis that opossums in closer proximity to human habitation would harbor higher prevalence and/or abundance of *P. turgida* due to consumption of certain food items such as compost, not found in rural settings. Increased interaction with domesticated animals and rodents was expected to increase parasitism in residential areas. Additional differences might include vegetational and landscape alteration in residential areas. Limitations of the study, mainly its reliance on road-kills, prevented application of the desired statistical design; few road-killed opossums were found in Garrett County during the collection period. However these data may serve as a beginning for further study.

Prevalence of *P. turgida* was correlated with opossum age. Nematodes occurred most frequently among adult opossums, followed respectively by subadults and juveniles. Low numbers of juveniles in the sample was an undesirable aspect of this comparison, but the trend appeared to be strong. Other workers (Cawthorn and Anderson 1975, Pence and Mienzer 1979, Gray 1981) also found greater prevalence of *Physaloptera* spp. in older host mammals.

This study indicated greater abundance in older opossums, possibly the result of continued ingestion of the parasite over time. Steady increase, as opposed to sudden large increase, was implied, though not proven. There was no evidence in this study, nor from the literature, that *P. turgida* multiplied within host opossums. Parasite abundance per host was correlated with host weight, which was in turn related to host age. Eighty-four percent of the nematodes counted in this study occurred in opossums with weight above the 1609.2 g mean. In general, therefore, heavier opossums were also older, and subject to ingestion of nematodes over longer time periods.

Although most nematodes were found in opossum stomachs, some were found in the esophagus and small intestine. The eight opossums that were trapped (dissected immediately or frozen) had nematodes only in stomachs, whereas road-killed opossums, which had lain for undetermined periods before being collected, had nematodes in various locations, including stomach, esophagus and small intestine. That trapped opossums lacked nematodes in the esophagus and small intestine might indicate *P. turgida* migration after death of the opossum. Gray (1981) indicated *P. turgida* was host specific.

The presence of hair unaccompanied by any other mammalian parts was considered the result of opossum self-grooming. All other contents recovered were considered food items of the opossum. Assumed preference of food items was based on percentage of opossums with the observed food item, with seasonal availability influencing these observations. Earthworms, insects and mammals were all important dietary supplements in spring, summer and fall, whereas mammals were important in winter. Therefore, the prevalence and abundance of *P. turgida* in opossums may be partially explained in terms of prevalence of intermediate and paratenic hosts in the diet.

Among the food items recovered from opossum stomachs, insects, including orthopterans and coleopterans possibly serving as intermediate hosts, and mammals, such as *Peromyscus* spp., serving as paratenic hosts, have been proven to carry *P. turgida* (Alicata 1937, Zago Filho 1959, and Gray 1981). However, the data herein suggest earthworms as a possible intermediate host, due to their notably greater occurrence in opossums with nematodes versus those without. Also, earthworms are detritus feeders, and could feed on embryonated *P. turgida* eggs.

Acknowledgements

This paper was adapted from the first author's 1992 M. S. Thesis entitled Parasitism and Anatomy of *Physaloptera turgida* (Rudolphi) in the Virginia Opossum (*Didelphis virginiana*), Frostburg State University, Frostburg, Maryland. Support for research was provided through Frostburg State University and the University of Maryland, Center for Environmental and Estuarine Studies/Appalachian Environmental Laboratory, Frostburg, Maryland.

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Recent Fisher (*Martes pennanti*) Sightings in Indiana County, Pennsylvania: Return of a Native?

Robert Lovich

Abstract: Although extirpated throughout much of its former range in eastern North America by the early twentieth century, the fisher is making a comeback in western Pennsylvania and neighboring states. This has been made possible by restocking efforts in West Virginia and New York, and more recently in north-central Pennsylvania. Recent observations of the fisher in Indiana County, Pennsylvania represent the first documented sightings of this species in the west-central portion of the Commonwealth in over one hundred years.

The fisher (*Martes pennanti*) is a large, arboreal North American mustelid closely related to weasels. It ranges across the northern United States and Canada. They range in size from 1.3 to 5.5 kg, and attain lengths as great as 63 cm, with males usually being larger than females. They are slender but strongly built animals (Figure 1) who regularly eat small mammals including porcupines (*Erithizon dorsatum*). Their original distribution extended south to Tennessee in the eastern United States, and to the high mountains of southern California in the west. Its modern range has been reduced greatly due to habitat destruction and trapping of the fisher in the 18th and 19th centuries for its pelt (Powell 1982).

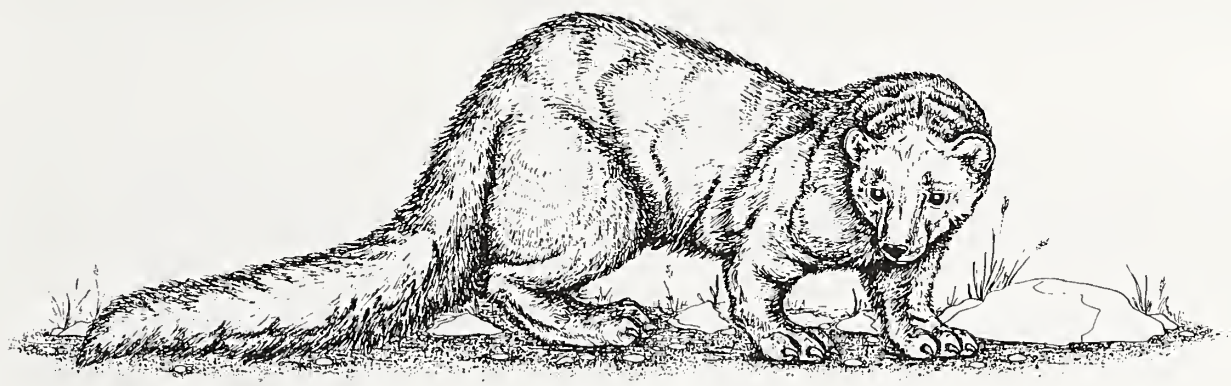

Figure 1. Adult fisher (*Martes pennanti*).

Fishers, apparently waifs from adjacent states, have been reported periodically in Pennsylvania during the latter part of this century (Cunningham 1985), despite the fact that they were believed to have been extirpated around the 1920's or 1930's (Williams et al. 1985). The purpose of this note is to report recent fisher observations in northeastern Indiana County, Pennsylvania.

Observations were made during the months of July and August, and again in December of 1995. During this time several independent sightings were made by three individuals, including myself, in the Village of Urey, Banks Township, in Northeastern Indiana County. Elevations in the immediate area range from about 365 to 670 m. Although the original forest was dominated largely by conifers prior to European colonization (Whitney 1990), today the area is characterized by mixed hardwood forests of mostly beech and maples, with hemlocks and white pine in mesic ravines, and oaks on ridgetops (Grimm and Roberts 1950). Viewing conditions were excellent during all periods of observation.

On July 30, 1995 between the hours of 1500 and 1600 an adult fisher of unknown sex was observed clearly by the naked eye in an open field at a distance of less than 100 m for approximately 10 minutes. Many of the distinctive field marks of a fisher (Burt and Grossenheider 1976) were clearly

evident (i.e. dark fur, cat-like size, long bushy tail, frosted facial hairs, and a long, slim body). After crossing a paved road that passes through the Village of Urey, it proceeded in a straight line across a recently mowed 1.2 ha hay field toward a stand of successional mixed hardwood and conifer forest at the edge of the field. The total distance it traveled while being viewed was approximately 100 m. It moved cautiously, 10-20 m at a time, and then paused for one minute or more. No tracks were observed due to the fact that the substrate was not conducive to track formation. Two other residents of Urey reported sighting an animal in August and in December of 1995 that perfectly matched the physical characteristics of a fisher. It is unknown whether these sightings represented one or more fishers. It should also be noted that residents reported these sightings to me because the animal was unfamiliar to them, and unlike foxes (both *Vulpes fulva* and *Urocyon cinereoargenteus*) and groundhogs (*Marmota monax*) that are commonly seen in the area.

Historically, the fisher was widespread in Pennsylvania (Cunningham 1985, Powell 1982), but was believed to be extirpated in the early 20th century. The last museum specimens obtained in Pennsylvania were collected in 1923, and the last known specimen from near the west-central part of the Commonwealth was killed in Forest County in 1893 (Williams et al. 1985). Fishers are known to trappers as one of the easier animals to trap (Young 1975), and considering the lack of fishers trapped in Pennsylvania during seasons for other mammals (Serfass et al. 1994), it is unlikely that remnant populations survived. Fishers may have persisted in nearby Clearfield County, Pennsylvania until near the end of the Nineteenth Century (Rhoads 1903). More recently, fishers have been reported from Lehigh, Clinton, Wayne, Pike, and Elk Counties (Cunningham 1985).

Although fishers were not extirpated from the Adirondacks in northern New York (Powell, 1982), recent re-introductions of the fisher into neighboring areas of West Virginia and southern New York (Wallace and Henry 1985, Pack and Cromer 1981, Handley 1979) are a more likely source from which fishers disperse into Pennsylvania. Cunningham (1985) reported that a fisher killed by dogs in Lehigh County, Pennsylvania was marked with an ear tag from a population reintroduced into the Catskills; a location approximately 160 air kilometers away.

In 1969, the Department of Natural Resources in West Virginia released 23 fishers (Handley 1979) which radiated widely from their release sites, with several trapped shortly thereafter in neighboring Maryland (Cottrell 1978) and Virginia (Handley 1979). Records from West Virginia indicate that fishers have been taken by legal trapping in that state each year since 1975 (data from the West Virginia Department of Natural Resources). For example, three and two fishers were trapped in Mineral and Preston Counties, respectively, in 1994, and fishers have been taken in those counties since trapping records began in 1975 (data from the West Virginia Department of Natural Resources). Fishers that are regularly trapped in Garrett and Allegheny Counties in Maryland presumably are descended from the stock reintroduced into West Virginia (Robert Colona pers. comm., Pack and Jayne 1987). Those counties in Maryland and West Virginia where fishers are regularly observed are within 160 air kilometers of Indiana County Pennsylvania.

Although fishers are often associated with arboreal habits (Powell 1982), a large portion of their time is spent on the ground (Powell 1979). Recent evidence suggests that fisher dispersal is common when habitat is available, and that time spent on the ground is much greater when dispersing (Powell 1982, Arthur et al. 1993, Handley 1979, Cliff Brown pers. comm.).

The ability of the fisher to move great distances would allow fishers in neighboring states to find habitat for re-colonization in the Allegheny Mountains and Allegheny Plateau of Pennsylvania. The Allegheny Mountains are situated in such a manner as to provide nearly unbroken ridges which are heavily forested and extend for great distances in a northeast-southwest direction. Thus, it is feasible for a fisher

to travel from West Virginia to western Pennsylvania along ridges and high mountainous areas where habitat is generally continuous. Studies of fishers in Manitoba showed that ridges provide habitat for the fisher's prey species and thus these are the areas they frequent (Raine 1983). The increase in forest cover in Pennsylvania since the 1920's (Whitney 1990) provides ample corridors for movement leading to repopulation of areas within the historical range of the fisher.

The area where the fisher(s) were observed has been altered by surface mining and timber harvesting during the last 100 years (Lovich and Lovich 1996), leaving a mosaic of second-growth forest and successional plant species. High fisher prey diversity has been shown to be positively correlated with mixed forest types (Kohn et al. 1993) so the overall habitat may be favorable for fishers and their foraging requirements. Indeed, porcupines and many small mammals, including red squirrels, mice and other prey animals favored by fishers are commonly found in the area (Doutt et al. 1977, pers. obs.). The surrounding multi-level forests, comprised of both deciduous and coniferous trees, provide additional requisites of this species (Allen 1983).

Efforts to reintroduce the fisher in Pennsylvania were initiated in December of 1994. By the time of my observation in July 1995, 44 had been released in north-central Pennsylvania, many within 70 km of Urey (Thomas Serfass pers. comm.). Plans call for reintroduction of approximately 100 fishers to four sites in north-central Pennsylvania (Bob Boyd pers. comm.). Whether the fisher colonizes Pennsylvania from adjacent states, is re-established by managers, or both, Pennsylvania is regaining an element of it's native mammalian fauna.

Acknowledgements

An earlier version of this manuscript benefitted from comments offered by Thomas Serfass, Jeff Lovich, and Gordon Kirkland, Jr. Special thanks to Helen Imhoff and George Lovich for reporting additional fisher observations. Thanks to Robert Colona and Leslie Johnston of the Maryland Department of Natural Resources and Cliff Brown of the West Virginia Department of Natural Resources. Thanks also to Bob Boyd, Assistant Director, Bureau of Wildlife Management, the Pennsylvania Game Commission. Kim Gray prepared the line drawing presented in Figure 1.

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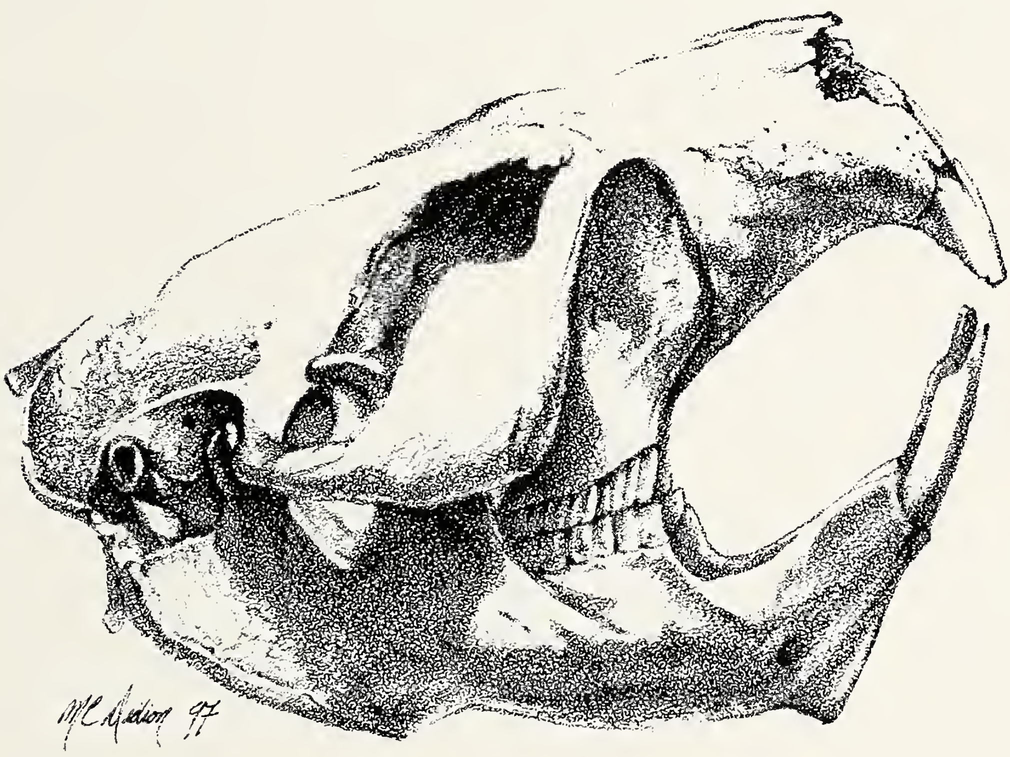

Volume 41, Number 3-4 July/December 1997

ISSN 0096-4158

The Maryland Naturalist

Volume 41, Number 3-4 July/December 1997

Contents

Arnold W. Norden and Donnell E. Redman, Editors

Mailing Date: December 30, 1997

Cover Illustration: Skull of beaver (*Castor canadensis*). The beaver, North America's largest extant rodent, can reach 4 feet (1.2 m) in length and weigh 60 pounds (27 kg). It was historically present throughout the country, but fur trappers extirpated the beaver from most of the eastern states. However, it has made a dramatic comeback, reappearing in streams lakes and ponds throughout the mid-Atlantic region. Although the presence of beavers may have a beneficial effect on aquatic systems, their habit of felling trees and building dams may make them unpopular in developed areas. This is an original drawing by Mary Ellen Didion.

The Mammals of Fort Belvoir, Virginia

Carl H. Ernst, Peter S. Miller, Arndt F. Laemmerzahl
and Timothy P. Boucher

Introduction

This report summarizes field notes on the mammals occurring on the Fort Belvoir Military Installation, Fairfax County, Virginia. It is the last of a series on the vertebrate animals found there; the first two reports having summarized the fish and herpetofauna (Ernst et al. 1995a, 1995c). These notes were collected during field surveys for local governments (1985-1990) under contracts from the Department of the Army (1987-1995), and incidental observations by the authors since 1985. The purposes of the report are to provide a current list of the species of mammals occurring at Fort Belvoir, and to compile within one publications available life history data for each species gathered at the installation. We hope that this information will serve as a reference for naturalists and scientists alike who wish to study and conserve the mammals of northern Virginia.

Fort Belvoir is located on the west bank of the Potomac River in Fairfax County, Virginia approximately 18 km southwest of Washington, D. C. It is crossed by U.S. Rt. 1 running east to west and by Backlick Road running north to south. The installation contains 3,503 ha of land, of which approximately one third has been developed. This has resulted in one of the largest natural landscapes remaining in the area surrounding the national capital. The undeveloped areas contain a variety of landforms and habitats typical of the coastal plain of the mid-Atlantic region. The elevation ranges from 10 m along the river shoreline to 50 m in the northeastern portion of the installation. The soil is predominately Dumfries sandy loam. The terrain consists of gently sloping (5% or less) wooded plateaus and flatlands which are dissected by creeks and their associated floodplains and wetlands. Some of the banks of the ravines formed by the tributaries of major creeks are steeply sloped (to 50%) and are covered with mature forest.

The open water habitats consist of a drainage system of creeks and small tributary brooks which flow into shallow semitidal bays and marshes that empty into the Potomac River. From west to east, the three major creeks crossing the installation are Pohick, Accotink and Dogue (Figures 1 and 2). Each creek has formed a semitidal bay at its mouth. Gunston Cove separates Fort Belvoir from Pohick Bay Regional Park on the Mason Neck Peninsula, and is formed by the merging of Pohick and Accotink bays. Dogue Creek forms another large bay along the southeastern boundary of the Belvoir Peninsula. Each bay also has extensive wetlands with emergent vegetation and low salinity which provide excellent cover and food for many species of vertebrates. The creeks previously mentioned have their headwaters outside the installation's boundaries and drain large watersheds in Fairfax County, which give rise to extensive floodplains and wetlands associated with them. Many of these have been augmented by beaver (*Castor canadensis*) activity in recent years (Davis 1992). There are numerous small tributaries to the creeks which typically are ephemeral or intermittent and meandering with undercut banks that traverse densely forested areas. These conditions are favorable for many small mammal species. Rocky brooks occur in some of the small tributaries and are important foraging sites for both small mammals and larger carnivores.

The undeveloped uplands of Fort Belvoir are covered with various seral stages of hardwood forests (maple, *Acer*; oak, *Quercus*; beech, *Fagus*; tulip poplar, *Liriodendron*; etc.), mixed pine (mostly Virginia pine, *Pinus virginiana*), and pine plantations (loblolly pine, *P. taeda*). A variety of management activities, including forest cutting (both clear and selective) resulting in open food plots for wildlife and reforestation, have created a complex of habitats on Fort Belvoir which has had a major

influence on the upland mammal fauna. The woodland edges are frequently used by hunting carnivores. However, some small mammals are benefitted more by stands of mature forests with abundant shade and humidity that likely represent the original landscape.

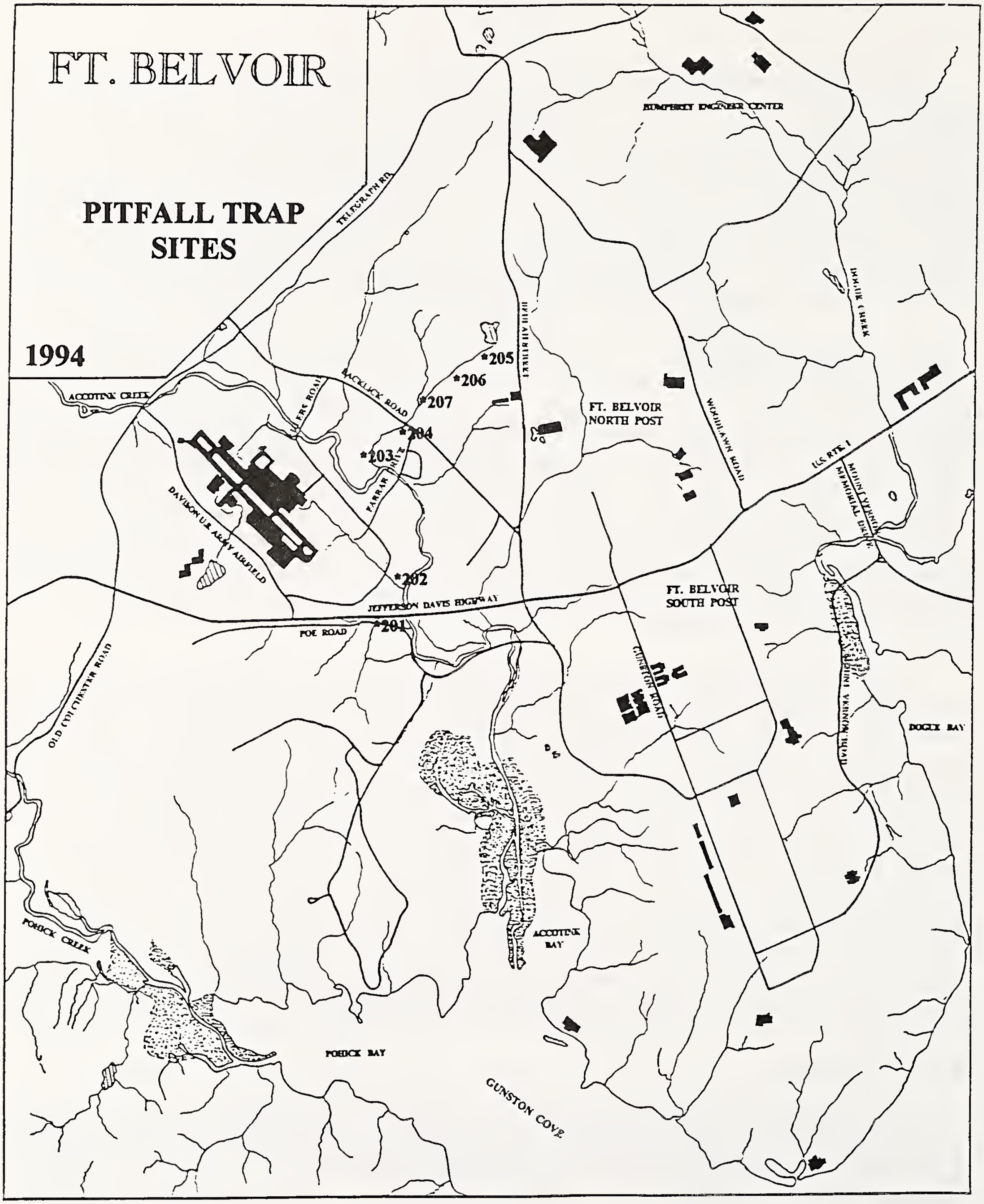

Figure 1. Location of Fort Belvoir pitfall trap sites (201-206) sampled during 1994.

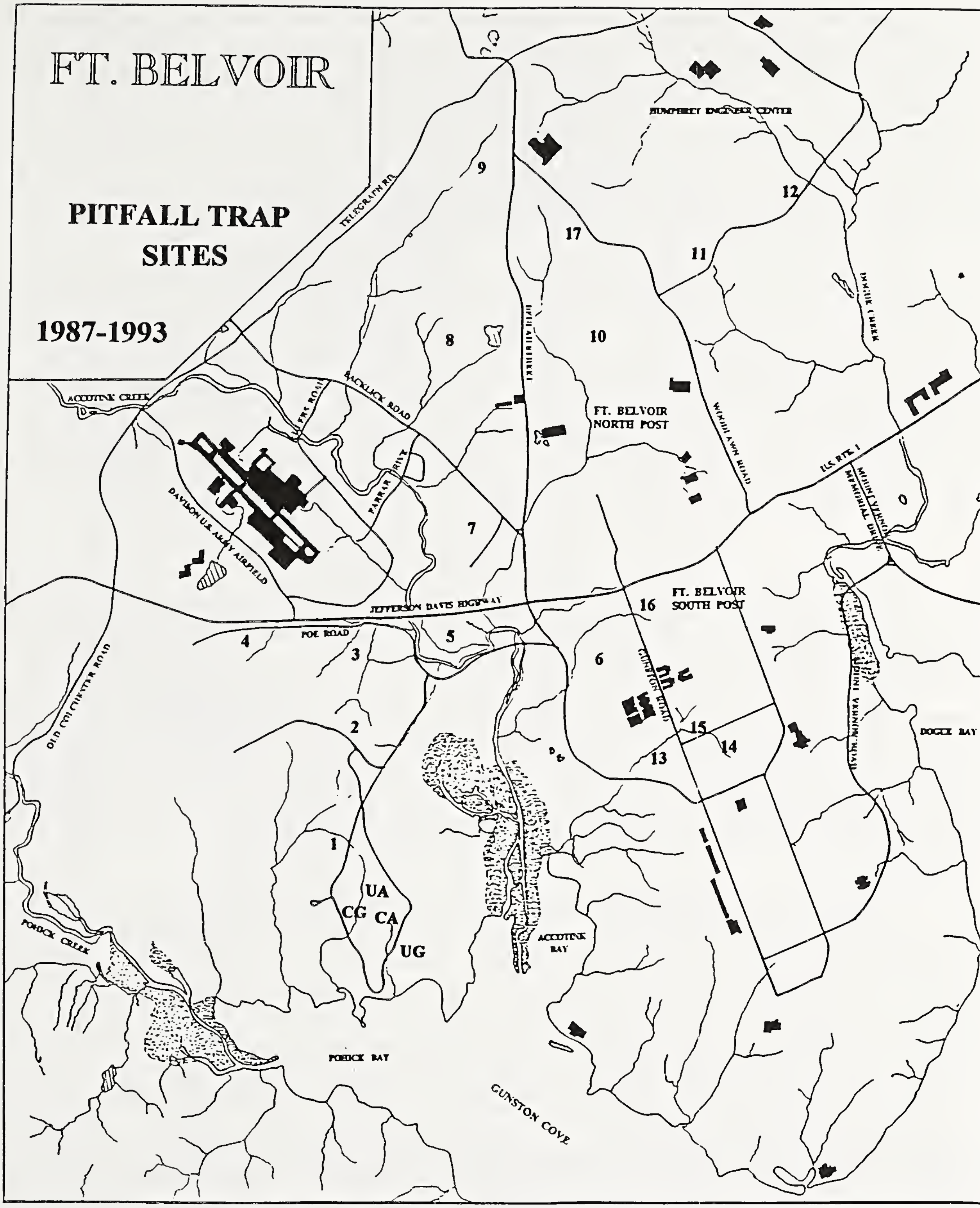

Figure 2. Location of Fort Belvoir pitfall trap sites (1-17, CA, CG, UA, UG) sampled from 1987 to 1993.

Within the aquatic system described above are several habitat features or microhabitats that are important to mammals. In the forested wetlands and floodplains along the creeks, large debris piles form during flood events creating ideal locations for voles, jumping mice and shrews. The beaver created wetlands are characterized by the downed trees which litter formerly forested areas. These logs provide ideal cover and highly productive foraging sites for shrews (*Sorex* sp.), white-footed mice

(*Peromyscus leucopus*), and chipmunks (*Tamias striatus*). Undisturbed woodlands on the installation support white-tailed deer (*Odocoileus virginianus*), gray and flying squirrels (*Sciurus carolinensis*, *Glaucomys volans*), chipmunks (*Tamias striatus*), various mice and voles (*Peromyscus*, *Zapus*, *Microtus*), shrews (*Blarina*, *Sorex*), the opossum (*Didelphis virginiana*), and carnivores (*Procyon*, *Lynx*, *Urocyon*, *Vulpes*, *Mephitis*, *Mustela*). Some old fields exist with patches of impermeable clay soils resulting in temporary pools forming after spring rains in March and April. Old fields support large numbers of meadow voles (*Microtus pennsylvanicus*) and shorttail shrews (*Blarina*, *Cryptotis*). Road side ditches and grass borders also serve as corridors and foraging areas for many small species.

In May 1993, the Fort Belvoir Wildlife Corridor Management Plan was approved ensuring that natural habitat and wildlife will have a priority in any future development planning. In the plan nearly 33% of the total land area of Fort Belvoir has been set aside for wildlife and natural resources preservation. Included are two tracts, open to the public, that have been set aside as refuges. The Accotink Bay Wildlife Refuge (1980) encompasses almost 750 ha of wetlands, marshes, free flowing streams, beaver ponds, and hardwood forested slopes situated at the mouth of Accotink Creek. The Jackson Miles Abbott Wetland Refuge (1990), totalling about 243 ha, situated along Dogue Creek in the northwestern sector of the installation, is comprised of free flowing brooks and streams, marshes, beaver and artificially constructed ponds, and mixed woodland slopes.

Methods and Materials

A vigorous collecting program was conducted from August 1987 to September 1995 consisting of various configurations of pitfall trapping systems, with and without drift fences, small mammal live trapping with Sherman collapsible traps, and large mammal trapping with various-sized Havahart and Tomahawk live traps. Twenty-eight different sites were sampled along a wildlife-genetic corridor that extends from the northwestern portion of the installation toward the southeast (Figures 1-3). Also a series of 15 culverts passing under major roads on the installation (Fig. 4) were examined for mammal sign, especially tracks (Murie 1974) in 1992, 1994, and 1995. For detailed descriptions, locations, and data summaries for each trapping and culvert site, see Ernst et al. (1990, 1991, 1992, 1994, 1995b). Prior to 1987, both banks of Accotink and Pohick creeks were trapped for small mammals under contracts with Fairfax County; results of those samples are also included here.

All pitfall traps consisted of 18.4 liter (5 gallon) plastic buckets buried with the upper rim flush with the ground surface. Plastic lids were placed 25-75 mm above the rim of each trap to protect trapped animals from overheating and desiccation. The lids also served to attract individuals seeking cover. Pitfall trapping offered the advantage of capturing secretive or nocturnal species not often discovered using other collecting methods, such as small shrews (*Cryptotis*, *Sorex*). The method worked well in upland situations, but in wetlands and on floodplains the buckets frequently flooded and required constant attention. The pitfall traps were checked three times a week and kept open for six week sample periods twice annually (March-May, August-September). Live traps were examined daily, and used over the same two six week periods. Each individual was identified to species, measured (total body length [TBL]; tail length [TL]; hindfoot length [HFL]), weighed, sexed (if possible), marked for future identification (toe clipping or ear notching for small species, spray paint numbers for larger ones), and released at the capture site. Other incidental data collected were: date, time, behavior, reproductive condition, injuries, parasites, etc. Dead individuals were brought to George Mason University for preparation and eventual entry into the institution's mammal collection (GMU).

Incidental observations of large mammals or their sign, especially deer, rabbits, etc., were recorded throughout Fort Belvoir, as were also records of mammals found dead on the installation's various roads (DOR). Mammal skulls discovered on the installation were identified by using the characteristics presented in Ernst (1975).

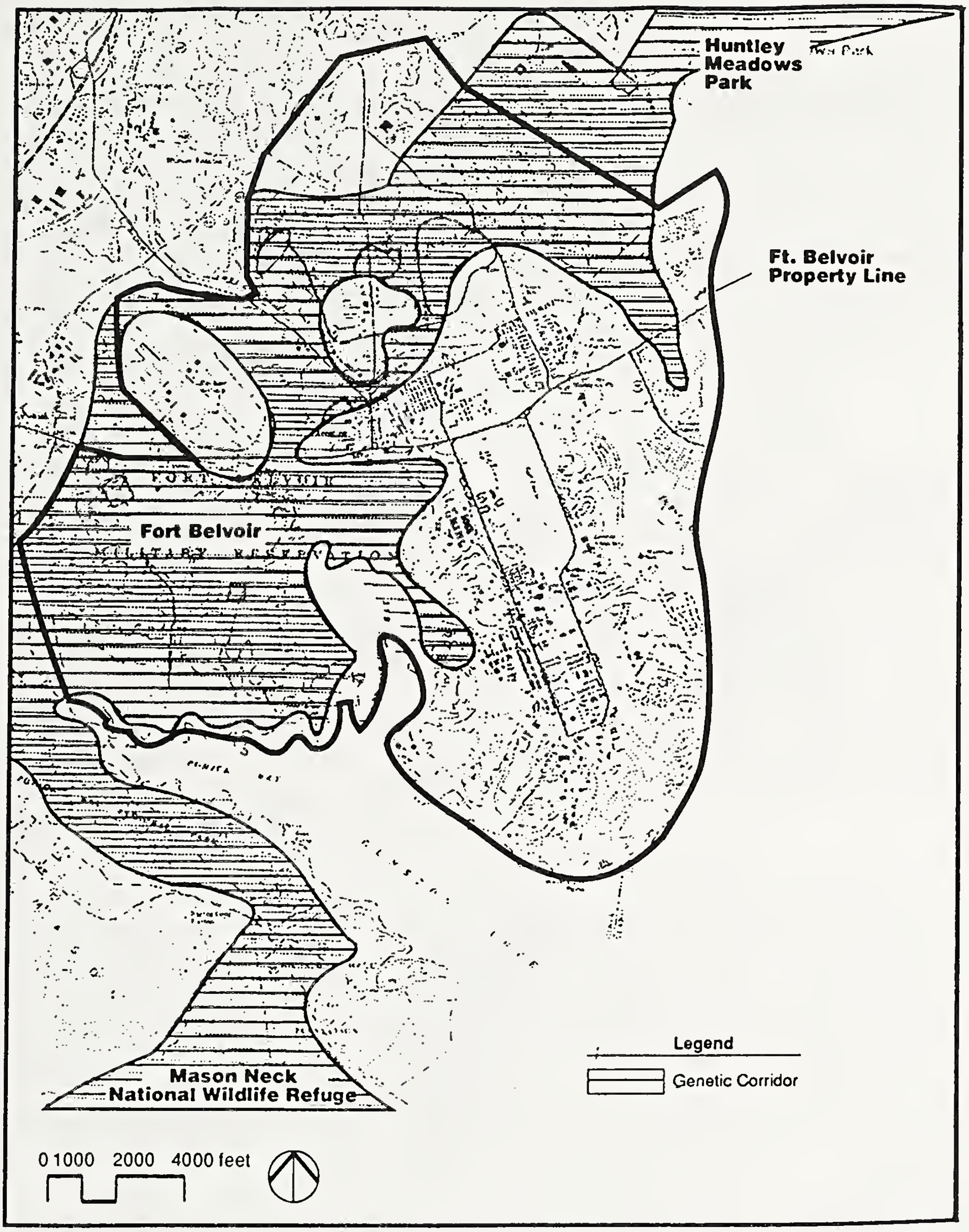

Figure 3. Wildlife genetic corridor extending through Fort Belvoir.

Bats were collected with mist nets at riparian sites along Accotink and Dogue creeks and at one roost building in an apartment complex adjacent to Fort Belvoir during the years 1991-1994 (Miller 1995). Standard parameters for each bat collected were recorded: species, sex, age, weight, forearm length (FA), height and direction in net, date, time, and reproductive condition.

The dental formula of each species is presented as the number of teeth (i = incisors, c = canines, pm = premolars, m = molars) on one side of the jaws, a diagonal line separates teeth on the upper jaw (listed first) from those on the lower jaw (listed second). The total number of teeth of the species is obtained by multiplying the number of teeth on one side by two. The taxonomy used in this report, unless otherwise stated, has been taken from Wilson and Reeder (1993). The common names of species are from Banks et al. (1987).

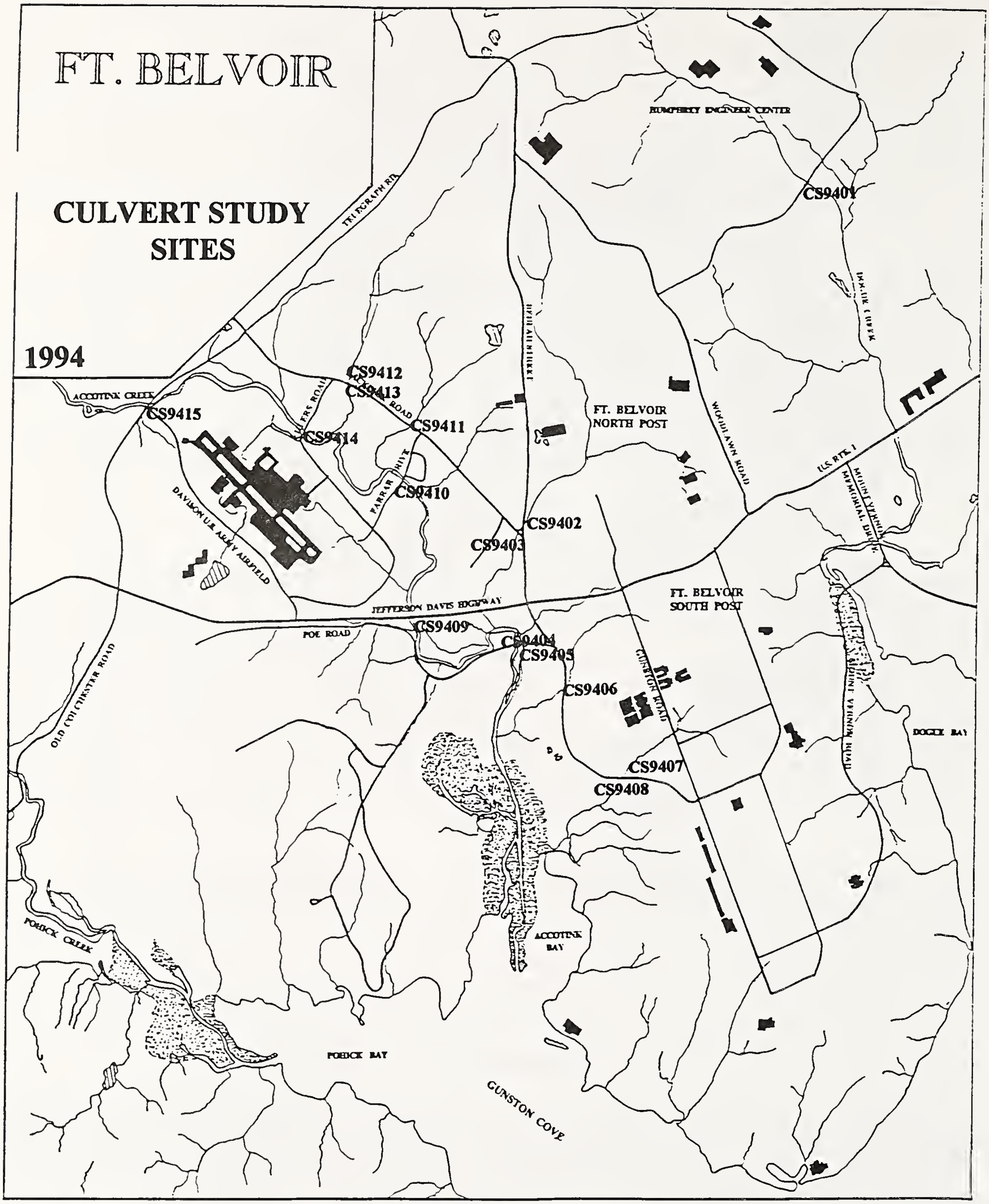

Figure 4. Location of Fort Belvoir culvert study sites (CS9401-CS9414) sampled during 1994.

Species Accounts

Didelphimorpha (American opossums)

Family Didelphidae (Opossums)

Didelphis virginiana **(Virginia Opossum).** This is the only marsupial (pouched mammal) in the United States. *Didelphis* is a stocky, rat-like animal with a pointed snout, naked ears, and a scantily-haired, almost scaly, prehensile tail. Its fur is generally grayish with a mixture of scattered long black or white-tipped hairs. The face is white, usually with a dark streak down the forehead and black ears. The legs are also dark. The innermost toe on the hindfoot lacks a claw and is thumblike and opposable for grasping. Females have an abdominal pouch. Average external measurements for seven northern Virginia adults in the GMU collection are TBL 69.4 cm (61.0-82.5), TL 28.1 cm (26.0-31.8), and HFL 5.9 cm (4.2-7.0). The Virginia opossum has more teeth than any other land mammal in the United States; the dental formula is i 5/4, c 1/1, pm 3/3, m 4/4 x 2 = 50. The subspecies in northern Virginia is *Didelphis virginiana virginiana* (McManus 1974).

Didelphis is one of the most commonly seen mammals in the region, especially as a dead carcass on our roads. Kelso (1992) considered it increasing in the region. It occupies a variety of habitats from brushy fields and woodlands to suburbs and even cities, but woodland edges seem to be preferred. Based on observations of road-killed individuals, the opossum is active, weather permitting, in every month, but less so in the winter when it spends much time in some shelter. These shelters are the same ones used during the day in the warmer months (Ernst pers. obs.): animal burrows, hollow trees, stumps, and logs, woodpiles, haystacks, open spaces beneath buildings, and storm sewers. At night it becomes active and forages on both the ground and in shrubs and small trees (Ernst pers. obs.). With the aid of its opposable "thumb" and prehensile tail it is an accomplished climber. On the ground, it slowly shuffles along, almost oblivious to its surroundings, and this often leads to its demise on our roads, where it is second only to the gray squirrel (*Sciurus carolinensis)* in numbers killed on northern Virginia highways each year.

Didelphis can be found almost anywhere on Fort Belvoir. A rather limited attempt at trapping medium-sized mammals in 1995 yielded opossums at live trap stations 201-202 and 206. It or its tracks were seen, or its skull found, at culvert sites 9401-02, 9404, 9405, 9408-10, 9412, and 9414. It has been recorded from both the Accotink Bay Wildlife Refuge and the Jackson Abbott Wetlands Refuge and along the lower floodplains of both Accotink and Pohick creeks. There is also a specimen from Fort Belvoir in the United States National Museum of Natural History, Smithsonian Institution (USNM 349915). Since 1988, this species has been one of the most frequently found DOR mammals at Fort Belvoir. Most have been killed on U.S. Rt. 1 or Backlick Road, but vehicles on Beulah, Lorton, and Pohick roads have taken their share.

The reproductive season is long, February to August in Maryland (Llewellyn and Dale 1964), with peak periods in the eastern United States from late January to late March and mid-May to early July (Hamilton 1958). Two litters are produced each year. The young are born prematurely and must further develop for approximately 60 more days attached to a teat in the female's pouch. The normal litter contains 6-9 young, although sometimes more young are born than there are teats (13) to feed them (Hamilton 1958, Reynalds 1952). The opossum is an omnivore and will eat almost anything of nutritional value it encounters: earthworms, insects, carrion, live mice, amphibians and reptiles, various fruits and grains (Dexter 1951, Hamilton 1958, Ernst pers. obs.), and it is not opposed to raiding garbage cans and trash bags. Major predators, next to vehicles, include owls, cats, and dogs. When badly frightened, *Didelphis* will enter a catatonic death feigning state where it becomes immobile with mouth open and eyes glazed or closed. This is, however, temporary, usually lasting only 1-2 minutes (Ernst pers. obs.).

Insectivora (Insectivores)

Family Soricidae (Shrews)

Shrews are the most energetic of all mammals; their extremely high metabolic rates keep them almost continuously searching for prey, and they consume close to their body weight in food each day. They are small, with short hair, pointed snouts, extremely small eyes, no pinnae (fleshy ear lobes), either a short or a long tail, and dark-pigmented teeth. Two species of short-tailed and two species of long-tailed shrews inhabit Fort Belvoir.

***Blarina brevicauda* (Northern Short-tail Shrew)**. The largest short-tailed shrew at Fort Belvoir is the gray *Blarina brevicauda*, which attains the size of a typical mouse. Average external measurements for 275 adults captured at Fort Belvoir are TBL 101.7 mm (75.0-175.0), TL 21.3 mm (13.0-34.0 mm), and HFL 13.5 mm (10.0-21.0). Its dental formula is i 3/1, c 1/1, pm 3/1, m 3/3 x 2 = 32. While the dental formula is identical to that of the two species of *Sorex* shrews found on Fort Belvoir, the skull of *Blarina* is about twice as large and normally five unicuspid teeth are visible from the side. The subspecies found in northern Virginia is *Blarina brevicauda kirtlandi* (George et al. 1986).

Blarina is the most common and widespread shrew in northern Virginia. At Fort Belvoir it has been captured at all trapping stations, the Accotink Bay Wildlife Refuge, the Jackson Abbott Wetlands Refuge, and along the floodplains of both Accotink and Pohick creeks. It also occupies the greatest variety of habitats on the installation, ranging from pine and deciduous woodlands, to grassy and shrubby fields, and marsh borders. More individuals (369) were collected than of any other species of mammal during our studies, and the USNM also contains a series from Fort Belvoir (506658-662, 512053).

It is active in every month, and during the day is seldom at rest. Much time is spent underground within mole tunnels and in shallow runways (about 10 cm deep) it digs itself. It may use echolocation to navigate through these dark underground tunnels (Gould et al. 1964).

The breeding season lasts from February to September (Christian 1969, Pearson 1944), and lactating females have been recorded in May-June and August-September at Fort Belvoir, matching the two peaks in reproduction noted by Blair (1940) and Hamilton (1929). Gestation takes about three weeks, and 5-7 young are born to a litter (Hamilton 1929, Pearson 1944). A nest under a log with six naked, blind young was found on 10 April, 1990 at the Jackson Abbott Wetland Refuge.

The saliva of *Blarina* is toxic to small animals (Ellis and Krayer 1955), and can produce an irritating bite in humans. *Blarina* is large enough to prey on other shrews (*Sorex*) and mice (*Microtus*, *Peromyscus*), but most food consists of earthworms, slugs, snails, spiders, centipedes, various insects, and plant materials (Blackburn and Andrews 1992, Eadie 1944, Hamilton 1941a). Prey, particularly snails, are often stored for a later feeding under rocks or logs, and we have often found such caches at Fort Belvoir.

This shrew is a favorite food item of hawks, owls, and various snakes and mammals (George et al. 1986, Ernst pers. obs.).

***Cryptotis parva* (Least Shrew)**. This shrew, like *Blarina brevicauda*, is short-tailed, but, unlike it, *Cryptotis* is small and brown. Average measurements of six adults in the GMU collection are TBL 73.0 mm (60.0-81.0), TL 15.0 mm (12.0-17.0), and HFL 9.3 mm (8.0-11.0). Because of its small size, the least shrew may be confused with the long-tailed shrews *Sorex hoyi* and *S. longirostris*, so it is necessary to check the dentition for an accurate identification. The dental formula is i 3/1, c 1/1, pm 2/1, m 3/3 x 2 = 30; usually only three unicuspid teeth are visible from the side since the fourth is so small as to be hidden from view. The subspecies in northern Virginia is *Cryptotis parva parva* (Whitaker 1974).

The least shrew seems to be the rarest shrew at Fort Belvoir. It was trapped only once at site CA in 1994, but it may be habitat exclusive to our woodland trapping sites. Its normal habitat is grassy, brushy fields (Hamilton 1944, Paradiso 1969), although Ernst has also trapped them in hedgerows.

Needless to say, we recorded no life history data at Fort Belvoir. Hamilton (1944) thought it probably breeds from March to November in the northern parts of its range. Based on embryo counts, 4-5 young (2-7) comprise a typical litter; the gestation period is 21-23 days (Whitaker 1974). Prey consists of earthworms, slugs, snails, spiders, centipedes, various insects (but largely beetles, lepidopteran larvae, grasshoppers and crickets), and some vegetation (Blackburn and Andrews 1992, Hamilton 1944, Whitaker and Mumford 1972). Remains of *Cryptotis* are often found in owl pellets, and various carnivorous mammals and snakes also take their share.

***Sorex hoyi* (Pygmy Shrew).** Two species of long-tailed *Sorex* shrews also occur at Fort Belvoir. The shortest of these, and usually considered the smallest of all mammals, is *Sorex hoyi*. Its back and sides are dark brown or reddish-brown to grayish-brown, the venter is grayish, and the tail is at least half as long as the body. Average external measurements of 82 individuals captured in pitfall traps at Fort Belvoir are TBL 71.9 mm (60.0-83.0), TL 26.3 mm (20.0-32.0), and HFL 8.2 mm (7.0-10.0). The dental formula is i 3/1, c 1/1, pm 3/1, m 3/3 x 2 = 32. The upper unicuspid teeth are crowded together so that only three are normally visible from the side, the fifth unicuspid is reduced to only a small peg, and the third unicuspid is also small. The subspecies in northern Virginia is *Sorex hoyi winnemana* (Long 1974).

At Fort Belvoir, the pygmy shrew has been collected at sites 1-5, 202, 204, CA, CG, UA, and UG. The USNM also has specimens (565888-897) collected at trap sites 1, 4, CG and UA. The pygmy shrew seems most common in areas with abundant logs and ground cover near waterways in both mesic deciduous woodlands and mixed deciduous/pine woods. It is active in every month, but little is known about its daily cycle. Most individuals were trapped between 1600 and 0800 h in May, June and August.

We recorded no life history data for Fort Belvoir *S. hoyi*, but it is known to breed elsewhere in the summer and produce 3-7 young per litter (Long 1974). It probably feeds on a variety of invertebrates, such as earthworms, slugs and snails, small insects, spiders and centipedes. Being so small, most terrestrial vertebrates at Fort Belvoir probably pose a threat.

***Sorex longirostris* (Southeastern Shrew).** This is the largest of the two long-tailed *Sorex* shrews occurring on Fort Belvoir. External measurements of 254 individuals captured in pitfall traps at Fort Belvoir are TBL 77.9 mm (60.0-90.0), TL 28.2 mm (17.0-36.0), and HFL 10.2 mm (9.0-13.0). Its back and sides are dark brown while the venter is yellowish-brown or grayish-brown; the tail is about half as long as the body. Since there is so much overlap in external characters with the pygmy shrew (*Sorex hoyi)*, the best means of identification is by dentition. The dental formula is i 3/1, c 1/1, pm 3/1, m 3/3 x 2 = 32. The inner ridge of the upper unicuspid teeth is unpigmented; normally, four unicuspid teeth are visible from the side; and the third unicuspid is usually smaller than the fourth. The subspecies in northern Virginia is *Sorex longirostris longirostris* (French 1980a).

The southeastern shrew reaches its northern limits in the vicinity of Washington, D. C. (Pagels et al. 1982). Habitat occupied at Fort Belvoir includes wet deciduous woodlands and drier mixed deciduous/pine woods with downed logs and abundant understory brush and ground level vegetation. Elsewhere it is known to inhabit old fields, marsh borders, fence rows, and roadsides (Blackburn and Andrews 1992, French 1980b); it should also be looked for in such habitat on Fort Belvoir. We have trapped it at sites 1-2, 4-13, 201-204, 206-207, CA, CG, UA, and UG. The USNM also has specimens (565898-908) collected at sites 4, CA and CG. The population of the southeastern shrew at Fort Belvoir is greater than that of the pygmy shrew. Since 1988 254 *S. longirostris* have been collected in pitfall

traps as compared to only 82 *S. hoyi*. The southeastern shrew is active all year round, with most daily activity occurring at night, probably between 2200 and 0600 h.

The breeding season may extend from March to October, but most reproductive activity probably takes place in the summer (French 1980b). Three to four young (1-6) comprise a litter; nests are usually constructed in or under decaying logs (French 1980b). A pregnant female was collected at Fort Belvoir on 5 May 1989, and lactating females were recorded during May and June of several years.

This small mammal has a voracious appetite; usual prey includes earthworms, slugs and snails, spiders, centipedes, ants, lepidopteran larvae, beetles, crickets, small mammals, and some plant materials (Blackburn and Andrews 1992, French 1980b, Whitaker and Mumford 1972). In return, *S. longirostris* is prey to hawks, owls, various snakes, domestic cats and dogs, and opossums (French, 1980b).

Family Talpidae (Moles)

Moles are easily recognized by their enlarged, hand-like forelimbs; short, smooth fur capable of being brushed both backward and forward; small eyes; and lack of ear pinnae. Two species occur at Fort Belvoir.

***Condylura cristata* (Starnosed Mole).** This is a wetland species that is easily identified by the fringing series of 22 fleshy appendages at the tip of its nose; its dark gray to black fur; relatively long, hairy tail; and its medium-sized hands (about half the width of the more common eastern mole, *Scalopus aquaticus*). Average measurements taken from four northern Virginia adults in the GMU collection are TBL 178.3 mm (153.0-200.0), TL 53.7 mm (50.0-57.0), and HFL 27.6 mm (25.0-30.0). The dental formula is i 3/3, c 1/1, pm 4/4, m 3/3 x 2 = 44. The subspecies in northern Virginia is *Condylura cristata parva* (Petersen and Yates 1980). Kelso (1992) reported *C. c. parva* is declining in Fairfax County, and Handley (1991) considered it threatened in Virginia and suggested it be given State Special Concern status.

Three starnosed moles were trapped at sites 3 and 4 in upland woods unlike its normal boggy, wetland habitat. However, seasonal brooks were nearby which the moles could have followed to enter the woods, and vernal pools occur in the area. Tunnels of *Condylura* are common in wet areas in the flood plains of Dogue, Accotink and Pohick creeks, and especially numerous in the Jackson Abbott Wetland Refuge where they often cross the bottom mud beneath the water of shallow pools. *Condylura* is a good swimmer, and seems to become more aquatic in the winter months (Hamilton 1931).

Apparently, only one litter of about five (3-7) young are produced each year in a nest above the waterline, normally in late spring (Eadie and Hamilton 1956, Hamilton 1931). Newborns are naked, blind and helpless, but are usually fully-haired by the eleventh day.

Condylura forages both day and night, but is probably most active between 2300 and 0900 h (Wiegert 1961). Prey consists almost exclusively of aquatic annelid worms and insects, but earthworms and beetle grubs are also taken (Hamilton 1931, Rust 1966). Chief predators at Fort Belvoir are probably hawks and owls.

***Scalopus aquaticus* (Eastern Mole).** This is the typical mole of lawns, fields and upland woods. It is much more common than the starnosed mole (*Condylura cristata)*, and may have increased in numbers in northern Virginia in recent years (Kelso 1992). *Scalopus* is light gray with a short naked tail, large hands and no fleshy appendages on its nose. Average measurements from 13 adults from northern Virginia in the GMU collection are TBL 144.3 mm (121.0-156.0), TL 25.1 mm (20.0-30.0), and HFL 17.4 mm (13.0-21.0). The dental formula is i 3/2, c 1/0, pm 3/3, m 3/3 x 2 = 36. The subspecies in northern Virginia is *Scalopus aquaticus aquaticus* (Yates and Schmidly 1978).

The specific name "*aquaticus*" is a misnomer; it is not aquatic in any way, and when possible this mole avoids water. Unlike the starnosed mole, the eastern mole prefers moist upland soils (clay loam or sandy), and at Fort Belvoir its burrows can be found crossing woodlands, old fields, lawns, and even the fairways of golf courses. It has been taken at trap sites 2-4, 10-12, 203, and along the floodplain of Accotink Creek.

Its burrows are of two types--temporary shallow surface runs, approximately 2-3 cm below ground level, and deeper (10-40 cm), more permanent runs. It can dig at a rate of 3-6 m/h (Merritt 1987). Occasionally the deep burrows are marked by a small surface soil mound ("mole hills") below which is a underground nest lined with vegetation. Mean area of male home ranges is about one hectare, while that of the female is about one-fourth this size (Harvey 1976). *Scalopus* is active all year; like other insectivores its high metabolism does not allow hibernation. But in the winter months it spends more time in the deeper burrows. The primary periods of daily activity are 0800-1600 h and 2300-0400 h (Harvey 1976); most surface activity occurs at night (Ernst pers. obs.).

Mating occurs in March and April, and a single litter of 2-5 young is born in late May or June (Barbour and Davis 1974, Conway 1959, Merritt 1987). To satisfy its metabolic demands, *Scalopus* eats often and consumes a variety of food items: earthworms, slugs, snails, spiders, centipedes, millipedes, isopods, ants, beetle grubs, and even some plant materials (Barbour and Davis 1974, Merritt 1987). Chief predators of the eastern mole are snakes, hawks, owls, weasels, domestic cats, domestic dogs, and foxes. Flooding of its habitat causes great mortality, and probably several of these inoffensive creatures are drowned each year on the lower flood plains of the creeks flowing through Fort Belvoir.

Chiroptera (Bats)

Family Vespertilionidae (Vespertilionid Bats)

***Eptesicus fuscus* (Big Brown Bat).** *Eptesicus fuscus* is the largest and most common bat captured at Fort Belvoir. Average external measurements of 187 individuals from the installation are: 65 males--FA (forearm length) 46.0 mm (42.0-50.0), weight 16.1 g (11.0-21.5); 122 females--FA 46.6 mm (43.0-52.0), weight 19.1 g (11.5-28.0). The glossy cinnamon-brown fur is long, darker above, lighter below and extends 25-33% down the uropatagium (interfemoral membrane enclosing the tail). Wings and ears are black; a raised flap (calcar) is present along the outer edge of the uropatagium. The ears are short, barely reaching the nostrils when extended forward along the snout, and the membranous, flap-like tragus is blunt-tipped or rounded. The dental formula is i 2/2, c 1/1, pm 1/2, m 3/3 x 2 = 32. The subspecies in northern Virginia is *Eptesicus fuscus fuscus* (Hall 1981).

This is the bat most closely associated with humans in northern Virginia. Favored day roosts include attics, barns, behind shutters and sliding doors, and between expansion joints beneath bridges. Two roosting colonies were found, both in human dwellings. Big brown bats residing in the Canterbury Square Apartments used Accotink Creek as a flyway to their foraging grounds at the Accotink Bay Wildlife Refuge. Bats roosting in the private Woodlawn Village foraged throughout the Jackson Abbott Wetland Refuge and southward into the marshy floodplain along Dogue Creek. Both roost sites were within one kilometer of their respective flyways, and both colonies foraged no more than two kilometers from their respective day roosts. No buildings on the installation were examined for bats, so the total numbers of *Eptesicus* using Fort Belvoir could not be determined, but it is probable that this bat occurs throughout the installation. Generally, the big brown bat was active from late April to early October, emerging from roosts for nightly foraging runs about 15 minutes after sunset. Bats were most active in the first two hours after sunset, but some individuals, usually males, were caught throughout the night. Females emerged again several hours before sunrise for a final foraging bout, returning to the roost at daybreak (Miller 1995).

Mating occurs intermittently from November until March. Sperm is stored until about early April when fertilization occurs (Barbour and Davis 1969). The gestation period is about 60 days; typical litters contain two (1-6) young (Barbour and Davis 1969). The young are weaned and can fly in about 30 days. The two roosts studied were maternal roosts composed predominately of adult females and their young. Individuals show remarkable site fidelity, remaining at or returning to the natal roost every year (Miller 1995).

The big brown bat feeds on a variety of flying insects, but its major prey at Fort Belvoir are beetles (Coleoptera) (Miller 1995). Predation is by hawks at dusk, owls at night, and snakes in the day roost (Barbour and Davis 1969, Miller pers. obs.).

***Lasionycterus noctivigans* (Silver-haired Bat).** Only one individual was collected along Accotink Creek. It is not resident in northern Virginia, but migrates through each spring from its southern winter range and each fall from its northern summer foraging range. The GMU collection has several other specimens from the region.

This is a medium-sized bat (measurements of the collected individual--FA 40.0, weight 12 g) with black fur interlaced with scattered silver hairs, especially on the shoulders and back. The uropatagium is moderately furred above, especially near the body. The rounded ears are black with a blunt tragus. The dental formula is i 2/3, c 1/1, pm 2/3, m 3/3 x 2 = 36. No subspecies have been described (Kunz, 1982).

The silver-haired bat inhabits woodlands and stands of trees in open country near ponds and streams. Summer roosts are normally in trees, usually behind loose bark or in tree holes, but sometimes open buildings are used (Kunz 1982). Hibernation sites include loose bark, hollow trees, rock crevices, and buildings; it rarely enters caves or mines. It emerges early in the evening and forages low to the ground. *Lasionycteris* is considered the slowest flying North American bat and is active throughout the night.

No life history data were recorded at Fort Belvoir, but elsewhere mating occurs in the fall, with fertilization in the spring. Females aggregate in small groups and give birth to two young in June (Barbour and Davis 1969). The young are weaned and flying by July and remain solitary throughout much of the year.

A variety of insect-types have been identified in this bat's diet: moths (Lepidoptera), cercopids (Homoptera), various dipterans (Diptera), true bugs (Hemiptera), ants (Hymenoptera), beetles (Coleoptera), stone flies (Tricoptera), and neuropterans (Neuroptera) (Black, 1974; Whitaker, et al., 1977, 1981a, 1981b).

***Lasiurus borealis* (Red Bat).** This bat is distinguished from other bats in the region by its unique color and completely furred uropatagium. Color varies from bright yellowish-red to orange or yellowish-gray. Males are usually more brightly colored than females. The wing membranes are black with reddish-brown or pink along the forearm and along the hand bones. The short, rounded ears are pale with a short tragus. The face is pale pink. Average measurements taken from 77 individuals collected at Fort Belvoir are: 40 males -- FA 39.7 mm (37.0-44.0), weight 20.2 g (7.0-12.5); 37 females -- FA 41.4 mm (39.0-45.0), weight 13.1 g (8.0-19.0). The dental formula is i 1/3, c 1/1, pm 1-2/2, m 3/3 x 2 = 30 or 32; the single upper incisor touches the canine and , if present, a minute upper premolar may be positioned between the canine and a fully formed premolar. The subspecies in northern Virginia is *Lasiurus borealis borealis* (Shump and Shump 1982).

Red bats were collected at three net stations along Accotink Creek and one at Dogue Creek. It was most abundant at Accotink Creek where the vegetation was characterized by a dense understory

of flowering dogwood (*Cornus florida*) and a closed canopy of hardwoods. Normally the red bat is found near forests or in more open cultivated areas where shade trees are present. Except during the mating season, it is generally solitary, roosting by day among tree leaves (Ernst pers. obs.). Red bats begin to forage 1-2 hours after sunset, flying high near or above treetop level. They forage over streams in the early part of the night. Most bats collected at Fort Belvoir were netted at least an hour after sunset, high in the netting, and close to the forest edge along a stream. There are two peaks in activity, one 2-3 hours after sunset, and a second lesser peak around 5-6 hours after sunset (Kunz 1973). *Lasiurus borealis* does not hibernate, but instead migrates south to areas of milder climate where it spends the winter (Davis and Lidicker, 1956).

Mating takes place in August and September with fertilization the following spring (Barbour and Davis 1969). One to four young are born in June after a gestation period of 80-90 days (Glass 1966).

The red bat's diet consists of a wide variety of insects, but mostly lepidopterans (Lepidoptera) and beetles (Coleoptera) (Whitaker 1972b). Predation comes from jays and hawks (Downing and Baldwin 1961, Elwell 1962, Hoffmeister and Downes 1964).

***Pipistrellus subflavus* (Eastern Pipistrelle).** This is the smallest bat captured at Fort Belvoir. Average measurements of 16 individuals netted on the installation are: six males -- FA 33.8 mm (33.0-35.0), weight 6.3 g (5.5-8.0); 10 females -- FA 34.4 mm (32.0-38.5), weight 7.5 g (4.0-10.0). Body fur appears yellowish-tan; but each hair is tricolored -- dark at the base, yellowish-brown in the middle, brown at the tip. The uropatagium has only a few hairs at its base. The wing membranes are blackish-brown; the face, ears and forearms are pinkish-brown. The ears extend slightly past the nose when pressed forward, the straight, blunt tragus tapers to a rounded tip. The dental formula is i 2/3. c 1/1, pm 2/2, m 3/3 x 2 = 34. The subspecies in northern Virginia is *Pipistrellus subflavus subflavus* (Fujita and Kunz, 1984).

Pipistrellus prefers open woodlands with large scattered trees, and is most commonly seen along the edges of woodlands. It was only collected at three sites along Accotink Creek. Generally its day roosts are among the leaves of trees, but buildings are occasionally used. This small bat migrates some distance to a cave to hibernate.

Mating occurs in the fall, fertilization in the spring, and, after at least a 44 day gestation period, two young are born in May or June (Barbour and Davis, 1969, Fujita and Kunz 1984). Like those of other bats, the newborn young are naked, blind and helpless. Weaning takes about a month, at which time the young can fly.

Foraging is in the early evening above the woodland canopy. Prey consists of a variety of small winged insects, but especially leafhoppers (Cicadellidae), ground beetles (Carabidae) and dipterans (Diptera) (Whitaker 1972b).

Five other bats have been recorded from northern Virginia, adjacent Maryland, or Washington, D.C. Though not collected during our surveys, these may conceivably occur at Fort Belvoir. The little brown bat (*Myotis lucifugus*) was expected, since an individual had previously been collected within a mile of Fort Belvoir at Gunston Hall on the Potomac River (GMU 1137), and because it has been reported from Washington, D.C. (Paradiso 1969). Its absence from our collections is puzzling. Possibly the population of little brown bats has declined in northern Virginia (the GMU collection has several other specimens from the region). Alternatively, its feeding niche may have been taken by one of four species collected (however, Ernst has taken it elsewhere in conjunction with all of the collected species).

Keen's myotis (*Myotis keenii septentrionalis*) has been collected in nearby Alexandria (USNM 14994) and Washington, D.C. (Paradiso 1969), but seems uncommon in the region. The small-footed myotis (*Myotis leibii*) has been collected at Plummers Island, Montgomery County, Maryland (Paradiso, 1969), but it is rare in the region.

The hoary bat (*Lasiurus cinereus*) was also expected at Fort Belvoir. It is not uncommon in northern Virginia, and has been collected in Alexandria (GMU 537) and Washington, D.C. (Paradiso 1969). It is a high, fast flyer that prefers coniferous woodlands, and it is possible our netting technique was not suitable for this bat.

The evening bat (*Nycticeius humeralis*) is known from Alexandria (USNM 117108), Fairfax County (USNM 268913), Washington, D.C., and Prince Georges County, Maryland (Paradiso 1969). However, we have never seen this bat in northern Virginia, and can not comment on its relative abundance.

Lagomorpha (Lagomorphs)

Family Leporidae (Hares & Rabbits)

***Sylvilagus floridanus* (Eastern Cottontail).** This is the only rabbit at Fort Belvoir. It prefers the edge of hardwood forest and old fields, but is equally at home on lawns and in the shrubs about the numerous buildings on the installation. Only juveniles have been trapped (sites 7, 9, 12), but it has also been seen at trapping sites 8, 10. 14, CA, and 203; culvert site 9409; and both golf courses. Several dozen are killed each year on U.S. Rt. 1, Backlick, Telegraph and other roadways on Fort Belvoir. Two specimens from Fort Belvoir are in the USNM collection (349712, 349916).

The eastern cottontail has soft, dense grayish-brown to reddish-brown fur on its back and sides, a cinnamon-colored patch on the nape and shoulders; and the venter, tops of the hindfeet and the short tail are white. The hindfeet are enlarged for hopping, and the ears are long. Average measurements of six adults from Fairfax County in the GMU collection are TBL 383.7 mm (355.0-426.0), TL 38.8 mm (35.0-45.0, and HFL 91.5 mm (82.6-100.0). The dental formula is i 2/1, c 0/0, pm 3/2, m 3/3 x 2 = 28. The second upper incisor is a small peg-tooth situated immediately behind the first incisor. The subspecies in northern Virginia is *Sylvilagus floridanus mallurus* (Chapman et al. 1980).

The eastern cottontail is a prolific breeder, and in our area 2-3 litters of 3-4 (1-6) young are produced annually (Hamilton 1940a, Paradiso 1969, Ernst pers. obs.). They mate in late winter; the gestation period is only about 29 days (Chapman et al. 1980). Young cottontails are born in a naked helpless state, and remain in a fur-lined depression (form), usually under a shrub until weaned about two weeks later. The earliest we have seen mobile young outside the nest in Fairfax County was 7 April.

Mostly crepuscular or nocturnal, the cottontail remains active all year. They feed on a variety of herbaceous plants, mostly grasses, clover or dandelions, but will also eat the tender shoots, bark and fruits of woody plants during the winter (Chapman et al. 1980, Paradiso 1969). Such activity can cause severe damage to ornamental trees and shrubs which are stripped of their bark and die (Ernst pers. obs.).

Most carnivorous mammals found in northern Virginia attack cottontails, including raccoons, weasels, foxes, feral dogs and cats, and bobcats (Martin et al. 1961). *Buteo* hawks, great-horned owls, and black rat snakes also prey on them (Chapman et al. 1980, Ernst pers. obs).

Rodentia (Rodents)

Family Castoridae (Beaver)

***Castor canadensis* (Beaver).** The beaver is the largest rodent in the region; external measurements of two in the GMU collection are TBL 750.2 mm (650.0-850.5), TL 220.0 mm (200.0-240.0), and HFL 145.5 mm (131.0-160.0). Probably everyone recognizes this animal by its large oval, flattened, scaly tail; its long brown fur; large webbed, heavily-clawed hindfeet; webbed forefeet; small ears; and squared-off snout. The dental formula is i 1/1, c 0/0, pm 1/1, m 3/3 x 2 = 20 teeth; the incisors are large and orange.

Although primarily nocturnal, the beaver may often be seen in the early morning or late afternoon foraging along the banks or in the streams of Fort Belvoir. Evidence of its presence in the form of tracks, felled and gnawed trees, drag channels, dams, lodges or bank burrows are common along all waterways in the installation. During our studies it has been recorded at four sites each along the lower flood plains of Accotink and Pohick creeks, at the Accotink Bay Wildlife Refuge, at the Jackson Abbott Wetland Refuge on Dogue Creek and at culvert sites 9405, and 9409-10.

Beaver are active all year, but spend more time in their shelters in the winter months. Basically wood-eaters, they feed on the tender parts, bark and leaves of a variety of hardwood trees and shrubs, and seem to favor ornamental fruit trees if these are available (Davis 1992, Ernst pers. obs.). Trees are felled and branches chewed off and dragged to a waterway where they are used to construct a dam; mud and smaller sticks are added to the dam to caulk it. If the pond formed behind the dam is deep and wide enough, *Castor* will construct a stick lodge in the middle with underwater entrances, otherwise it will build its lodge on the bank or dig a bank burrow if the stream is narrow.

Three or four young are born in late winter (Jenkins and Busher 1979), and the pups make their outside appearance in late March or April at Fort Belvoir.

Predators of beavers must be large, as this animal can bite savagely. At Fort Belvoir only the bobcat (*Lynx rufus*), and, possibly, large domestic dogs (*Canis familiaris*) qualify, but several are found DOR on the installations roads each year.

Formerly the subspecies *Castor canadensis canadensis* was present over almost all Virginia (Hall, 1981), but was extirpated (Handley 1991). In the mid-1970s Virginia's Department of Game and Inland Fisheries reintroduced beavers of the subspecies *Castor c. canadensis* into northern Virginia. Since that time it has increased in numbers to the point of often being a destructive nuisance (Davis 1992).

Family Muridae (Rats, Mice, & Voles)

***Microtus pennsylvanicus* (Meadow Vole).** Voles are mice with rounded snouts, small eyes and ears, short tails, and soft dense fur. The meadow vole is the largest of the two voles inhabiting Fort Belvoir; average external measurements of 18 individuals captured at Fort Belvoir are TBL 147.0 mm (128.0-175.0), TL 37.4 mm (30.0-49.0), and HFL 20.2 mm (9.0-25.0), the tail is often twice as long as the hindfoot. Its dorsal and lateral fur is dark brown to grayish-brown, the venter is silvery or buffy-white, and the tail is bicolored. The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16; the second upper molar is unique in having an extra posterior loop. The subspecies in northern Virginia is *Microtus pennsylvanicus pennsylvanicus* (Reich 1981).

Microtus pennsylvanicus has been caught at trap sites 1-2, 7, 9-12, 14, 201,-203, 205-207, CA, UG, and one boggy site on the lower flood plain of Pohick Creek. While widespread on the installation, no more than three individuals were taken at any one site. Seven additional specimens from Fort Belvoir are in the USNM collection (506654-657, 512062-64).

Getz (1985) noted that the meadow vole is a resident of small, isolated, or ephemeral habitat patches. Preferred habitats always include areas composed primarily of perennial grasses: meadows, old fields, bogs, marsh borders, and grassy roadsides. It is also found in woodlands, as were most of our trap sites, if there is sufficient grass cover; but woodland populations have lowered reproductive success (Grant 1975), and this may partially explain the low numbers of captures at our sites. This vole constructs extensive surface runways in the grass, and its presence can often be confirmed by finding these runs and the small green piles of grass cuttings *M. pennsylvanicus* stores there. Although its nest may be a ball of grass at the end of a runway, we have noted that most construct underground burrows 5-10 cm deep in northern Virginia. It is active both day and night all year round. Primary spring and summer foods are grass and sedge stems, some seeds (particularly in autumn) and the bark and roots of shrubs in winter (Paradiso 1969, Riewe 1973, Zimmerman 1965). Winter gnawing on shrubs may be quite destructive.

Breeding in the area of Washington, D.C. may be year round, but there is usually a hiatus during the colder portions of winter (Paradiso 1969). The gestation period is 21 days (Dieterich and Preston, 1977). A typical litter has 4-6 (1-11) young and up to 17 litters may be produced each year (Hamilton, 1941b, Keller 1985, Paradiso 1969, Tamarin 1977). Sixteen northern Virginia litters examined by Ernst averaged 4.8 young (3-8). Weaning takes 12-14 days, but only about 63% of the young are successfully weaned (Morrison et al. 1976).

Microtus pennsylvanicus is a favorite food of many snakes, hawks, owls, weasels, skunks, feral dogs and cats and bobcats (Reich 1981).

***Microtus pinetorum* (Pine Vole).** The common name "pine" vole is a misnomer as this mouse is seldom found in pine woods. *Microtus pinetorum* is best distinguished by its short tail (seldom over 21 mm long, but over 33 mm long in the meadow vole (*M. pennsylvanicus*), its chestnut-brown fur, gray venter, and dentition. Average external measurements for 77 individuals trapped at Fort Belvoir are TBL 112.7 mm (90.0-127.0), TL 19.4 mm (15.0-26.0), and HFL 16.0 mm (10.0-20.0). The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16; the second upper molar lacks the additional posterior loop found in *M. pennsylvanicus*, and the third upper molar resembles a fir tree when viewed from below. The subspecies in northern Virginia is *Microtus pinetorum scalopsoides* (Smolen 1981).

We caught many more pine voles (105) than meadow voles (25) at Fort Belvoir. The pine vole seems to be less habitat restricted on the installation than the meadow vole. Most captures have been in deciduous, hardwood forest where leaf litter is abundant (trap sites 1-16, CA, CG, UA, UG). Getz (1985) reported that it needs a large, contiguous, relatively stable habitat. It is a subterranean dweller that either digs its own burrow or uses the tunnel systems of moles. Natural burrows are often dug among tree or shrub roots and extend 10-20 cm deep in Fairfax County. Our trapping indicates that surface activity is primarily nocturnal at Fort Belvoir. It does not hibernate during the winter, but does spend more time underground.

Based on the capture of lactating females, the breeding season in northern Virginia lasts at least from March to November. The gestation period is about 24 days (Kirkpatrick and Valentine 1970), and the first young are born in late March or early April in Fairfax County (12 nests, Ernst pers. obs.). Weaning occurs in 17-21 days; at 16 days few are nursing and most take solid food (Geyer and Rogers 1979, Hamilton 1938). Several (1-4) litters of 2-4 young are produced each year (Keller 1985); 12 Fairfax County litters examined by Ernst averaged 2.8 (2-4) young.

In summer the pine vole feeds mostly on grass and forb roots and stems, in autumn more seeds and fruits are eaten, and over the winter bark and roots comprise most of the diet (Benton 1955, Cengel et al. 1978). Bark chewing can be very destructive by girdling small trees and shrubs.

Chief predators in Fairfax County include snakes (*Agkistrodon*, *Coluber*, *Elaphe*), hawks, owls, raccoons, weasels, skunks, foxes, feral dogs and cats, and the bobcat (Smolen 1981, Ernst pers. obs.).

***Mus musculus* (House Mouse).** This small rodent is not native to North America, but was introduced from Europe and now lives both in feral populations and as a pest near human habitations. Its upper and lower parts are gray to yellowish-gray with lighter feet; a long, scantily-haired, scaly tail; a long pointed nose; and large ears. External measurements of 14 adults from northern Virginia in the GMU collection are TBL 149.8 mm (101.0-167.0), TL 71.8 mm (54.0-83.0), and HFL 16.1 mm (14.0-18.0). Its dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16. The front surfaces of the upper incisors are not grooved, but the upper incisors do have a notch into which the tip of the corresponding lower incisor fits. Crown cusps on the upper molars are arranged in transverse rows of three. The subspecies in northern Virginia is probably *Mus musculus domesticus* (Hall 1981).

Most house mice at Fort Belvoir probably live within buildings, as each year the installation's pest control unit must exterminate them in some buildings and residences. But we have trapped them at trap sites 3, 4, 9, 13, 201, 206, and CG. The USNM has two specimens from Fort Belvoir (506667-668).

Mus is nocturnal and active both indoors and out all year long. Those living feral inhabit burrows they dig themselves. A variety of foods are eaten, including seeds, fruits, insects, and products stored by humans. In this latter regard, the house mouse can be a serious nuisance.

Breeding occurs throughout the year; the young are born in a loosely-structured nest of grass, paper, string or cloth after a gestation period of 19-21 days (Paradiso 1969). A female can produce up to 13 litters of 5-6 (3-10) young each year, and so can populate a building very quickly. Newborns are blind, naked and helpless, but are weaned in about 21 days.

The same predators at Fort Belvoir that take *Microtus* or *Peromyscus* (see below) will prey on *Mus musculus*.

The eastern harvest mouse (*Reithrodontomys humulis)* closely resembles the house mouse, but has grooved upper incisors and the cusps on the crowns of its upper molars in rows of two. We did not find this mammal at Fort Belvoir, but it has been collected nearby in Alexandria (USNM 117108), and may possibly be present in some of the old fields about the installation.

***Ondatra zibethicus* (Muskrat).** This is the largest and most aquatic of the voles in northern Virginia. Average measurements of four adults from Fairfax County in the GMU collection are TBL 48.7 cm (44.5-55.0), TL 22.0 cm (20.0-24.0), and HFL 8.0 cm (7.5-9.0). Most often confused with the much larger beaver (*Castor canadensis*), the muskrat has a narrow, laterally compressed tail with a bordering ridge while that of the beaver is broad and flattened from top to bottom. The muskrat's fur is long and grayish to reddish-brown, the venter is also reddish-brown. The feet are dark brown to black with webbed hindtoes. The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16; the front surface of the upper incisors is yellowish-orange.

Muskrats have been seen in Accotink, Dogue and Pohick creeks; many of their tributary brooks; and are particularly abundant in the marshes at the mouths of the three primary streams and at the Jackson Abbott Wetland Refuge. At the latter sites their presence is revealed by the mound-like lodges of marsh reeds and the feeding platforms of cut reeds they construct (beavers construct stick lodges). In the streams proper, muskrats live in bank burrows. In addition to the above areas we have also recorded *Ondatra* at culvert 9414, and have found one DOR at the Accotink Creek bridge on U.S. Rt. 1. It may be active at any hour, but most activity occurs in the early morning or evening.

In this region, breeding occurs throughout the year except November and December (Smith 1938). Most young are born from mid-April to mid-September, and a female may carry a litter while nursing a previous one (Hamilton 1949). Two to three litters are produced each year. Typical litters have 4-6 (3-7) young, which are born after a gestation period of about 30 days (Hamilton 1963, Paradiso 1969). *Ondatra* gets its common name from musk secreted from prepucial glands during the breeding season.

The muskrat is chiefly a vegetarian, feeding on a variety of marsh and aquatic plants such as arrowhead, cattails, burreed, cutgrass, waterlilies, and panicgrass (Martin et al. 1961, Smith 1938, Hamilton 1963). Animal prey includes freshwater mussels, crayfish, small turtles (especially those hibernating; Ernst pers. obs.), and possibly fish and carrion (Paradiso 1969).

Muskrats fall prey to human traps and vehicles, foxes, and bobcats, and we have found their skulls in owl pellets at the Accotink Bay marsh.

***Oryzomys palustris* (Marsh Rice Rat).** This native, medium-sized rat superficially resembles the introduced Norway rat (*Rattus norvegicus*). Its back and sides are grayish-brown with some yellowish hairs interspersed; the venter and feet are white; and the tail, long, scaly, and scantily-haired. External measurements of eight adult *Oryzomys* collected along the lower Accotink and Pohick creeks are TBL 225.4 mm (196.0-271.0), TL 108.7 mm (92.0-126.0), and HFL 30.9 mm (28.0-33.0). The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16. The rice rat is more bicolored than *Rattus norvegicus*, which seldom has a white venter, and has two rows of cusps on its upper molars, while *Rattus* has three. The subspecies at Fort Belvoir is *Oryzomys palustris palustris* (Wolfe 1982).

Twenty rice rats were trapped in the grassy wetlands along the lower Accotink and Pohick creeks of Fort Belvoir, where the rodent inhabits bank burrows. It is a good swimmer and is active all year. Foraging mostly takes place at night. Its plant foods reflect its habitat choice (*Spartina*, *Tripsacum*, *Elymus*; Hamilton 1946), but some animals are also consumed (snails, crabs, crayfish, insects, fish, bird eggs; Barbour and Davis 1975, Wolfe 1982, Ernst pers. obs.). Owls hunting along the banks of the waterways are the most important predators, and we have found rice rat skulls in regurgitated owl pellets at Fort Belvoir and elsewhere along the Potomac River. Marsh hawks and some snakes (*Elaphe*, *Coluber*) probably also prey on them at Fort Belvoir.

The breeding season is long, probably extending from March to November in this region, and possibly up to nine litters of 1-7, usually 3-5, young are produced each year (Hamilton 1946, 1949; Paradiso 1969). The gestation period is about 25 days (Barbour and Davis 1974) and actively nursing females may also be pregnant (Hamilton 1949).

***Peromyscus leucopus* (White-footed Mouse).** *Peromyscus leucopus* is a mouse with a long snout, large ears, prominent black eyes, short hair, and a long tail. Adult fur is two-toned with the back and sides reddish-brown and the underside white. A darker brown middorsal stripe is often present. The dorsal surface of the feet is white, and the tail is only slightly darker on top than beneath (it is not sharply bicolored as in the deer mouse, *Peromyscus maniculatus*). Average external measurement of 211 individuals trapped at Fort Belvoir are TBL 143.0 mm (114.0-190.0), TL 67.9 mm (50.0-79.0), and HFL 19.9 mm (10.0-23.0). The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16; the cusps on the crowns of the upper molars are arranged in rows of two. The subspecies in northern Virginia is *Peromyscus leucopus noveboracensis* (Hall 1981, Lackey et al. 1985).

The white-footed mouse is one of the most populous woodland mammals at Fort Belvoir. We captured a total of 275 individuals at all the trap stations except CG, and another 132 along the flood plains of Accotink and Pohick creeks. In addition, it was recorded at culvert sites 9409-10 and 9414, at both the Jackson Abbott Wetland Refuge and the Accotink Bay Wildlife Refuge. The USNM has

12 specimens from Fort Belvoir (506663-666, 512054-61). It reaches its greatest density on the installation in deciduous woods with numerous fallen logs and stumps, but it also inhabits mixed woodlands and sometimes enters buildings. It is a good climber that readily ascends trees or shrubs to escape when disturbed. Nest sites are often above ground level (Lackey et al. 1985), but we have also found its nests under rocks and logs or within hollow logs and stumps. These nests were lined with hair, milkweed down, grass, leaves or moss. *Peromyscus leucopus* does not dig its own burrow, but will use that of other small mammals. The white-footed mouse is primarily nocturnal, and is active in every season (in the winter it is sometimes diurnal).

Breeding in northern Virginia is mostly confined to the warmer months of the year, but begins in February and lasts to November (Ernst pers. obs.); a lactating female was trapped on 21 February. A female produces several litters during this period, and can be pregnant while nursing a previous litter. Gestation takes 23-25 days in nonlactating females and up to 37 days in lactating females (Layne 1968). The blind, naked young are born in the nest, and leave it in 19-25 days. Juvenile white-footed mice are gray and white but molt and become brown and white at maturity. A typical litter in northern Virginia contains 4-6 young; mean 4.8 in 21 litters examined by Ernst. Most litters are born in the spring or in later summer. One female gave birth to three young while in a live trap on 21 April.

Peromyscus leucopus is strongly insectivorous, but snails, grasses, seeds, small fruits, grains, acorns, and hickory nuts are also eaten (Hamilton 1941a, Lackey et al. 1985, Paradiso 1969, Ernst pers. obs.). Some seeds may be stored in or about the nest. Bones and cast off antlers are often gnawed for calcium. Being so plentiful, many northern Virginia animals rely on this rodent as primary prey: hawks, owls, snakes, raccoons, skunks, weasels, foxes, feral dogs, feral cats, and bobcats. Even the short-tail shrew (*Blarina brevicauda*) regularly preys on it.

***Peromyscus maniculatus* (Deer Mouse).** The deer mouse apparently has recently invaded northern Virginia from Maryland; it was first trapped at Dulles Airport by Peacock and Peacock in 1962. The invading subspecies is *Peromyscus maniculatus bairdii*, the prairie deer mouse. It is found in areas primarily vegetated with annual and/or biennial grasses, and is often common in old fields in Fairfax County. At Fort Belvoir we have trapped it at site 6, five sites along the lower floodplain of Accotink Creek, and four sites along the flood plain of Pohick Creek. It is primarily nocturnal and is active in every month.

The deer mouse closely resembles the white-footed mouse (*Peromyscus leucopus*) in body form and coloration of adults and juveniles. The two mice also share the same dental formula and molar crown cusp pattern, but can be told apart by the shorter, more distinctly bicolored tail in *P. maniculatus*. External measurements of 25 deer mice from Fairfax County in the GMU collection are TBL 142.6 mm (133.0-169.0), TL 69.9 mm (57.0-74.0), and HFL 19.8 mm (15.0-21.5).

The breeding season in Fairfax County lasts approximately from March to November; most lactating females are found in April-June. The gestation period is 22-25 days for nonlactating females and 23-29 days for those nursing a previous litter (Layne, 1968). At least three litters of 2-6 naked, blind young can be produced each year (Hamilton 1963, Paradiso 1969, Ernst pers. obs.). Weaning takes about 18-24 days (Layne 1968). Primary foods are seeds, mast and small insects; seeds may be stored in or near the nest (Hamilton 1963) which is often an underground burrow or under a board or log. The same animals that eat *Peromyscus leucopus* prey on *Peromyscus maniculatus*.

***Rattus norvegicus* (Norway Rat).** This is a brown to grayish-brown rat with a white or gray venter; light feet; a long, pointed nose; large ears; and a long, scantily-haired, scaly tail. External measurements of 17 adults from northern Virginia in the GMU collection are TBL 280.8 mm (196.0-420.0), TL 129.3 mm (95.0-182.0), and HFL 38.1 mm (31.0-60.0). The dental formula is i 1/1, c 0/0, pm 0/0, m 3/3 x 2 = 16; the cusps on the crowns of the upper molars are arranged in transverse rows

of three (the similar marsh rice rat, *Oryzomys palustris*, has the cusps on its molar crowns arranged in rows of two). The subspecies in northern Virginia has not been determined.

The Norway rat is the largest and most destructive of the two murid rodents introduced from Europe that reside at Fort Belvoir. Like the house mouse, *Mus musculus*, it is usually found around buildings, but also lives in sewers, trash dumps, and is feral along the edges of fields and marshes. It is often found in wet habitats and is a good swimmer. When feral, *Rattus norvegicus* lives in a complex burrow/tunnel system that the rats dig themselves. Usually a clan of 10-12 rats occupy the burrow system, which they viciously defend against rats from other clans (Calhoun 1962). We have recorded it at trap site 202; culverts 9409, 9410, and 9414; and at one site on the lower flood plain of Pohick Creek. Each year the pest control unit must rid buildings or residences of this destructive beast. It is nocturnal and active all year.

Breeding is year round, and after a gestation period of 21-22 days 6-8 (2-23) blind, naked, helpless young are born in a nest chamber within the burrow. Weaning takes about three weeks, and a female may be pregnant with a second litter while still nursing the first (Calhoun 1962). Females may produce 5-8 litters per year (Barbour and Davis 1974, Paradiso 1969).

Rattus norvegicus will eat almost anything, both animal or vegetable. It also will gnaw through wood, plaster, and other building materials to gain entrance; it has been known to strip the insulation from wires causing fires. Rats of the genus *Rattus* constitute another danger in acting as hosts of fleas and lice that spread diseases, such as bubonic plague and typhus fever, to humans. Enemies at Fort Belvoir include humans, black rat snakes (*Elaphe obsoleta*), hawks, owls, bobcats, and possibly weasels and feral cats.

Family Sciuridae (Squirrels)

***Glaucomys volans* (Southern Flying Squirrel).** This is our smallest tree squirrel. It has soft, grayish-brown fur on the sides and back; a white venter; a gray, feathery tail; large black eyes; and a gliding membrane (patagium) composed of a fold of fully haired skin extending from the forelegs to the hindlegs. This gliding membrane is not found in other squirrels at Fort Belvoir. External measurements of five adults collected in northern Virginia in the GMU collection are TBL 231.4 mm (201.0-253.0), TL 101.2 mm (96.0-107.0), and HFL 26.6 mm (23.0-31.0). The dental formula is i 1/1, c 0/0, pm 2/1. m 3/3 x 2 = 22, where the first upper premolar is a small peg. The subspecies in northern Virginia is *Glaucomys volans volans* (Dolan and Carter 1977).

Five southern flying squirrels have been captured on the installation at trap sites 9(2 individuals), 14, 207, and at one site along the lower Accotink Creek. *Glaucomys volans* is common in the mixed hardwood woodlands on the installation, but because of its primarily nocturnal schedule is seldom seen. It is active all year long, but spends the daylight hours sleeping in a tree hole lined with shredded bark and/or leaves. It is quite sociable, and several may occupy the same tree cavity at a time. These gentle creatures can often be induced to make their presence known if one strikes a hollow tree with a stick; several curious squirrel faces may then appear in the entrance of a hole. *Glaucomys* has apparently taken up the nocturnal niche to avoid competition with the larger, more aggressive diurnal tree squirrels (*Sciurus*, *Tamiasciurus*).

Foraging occurs both in trees and on the ground; those captured at Fort Belvoir were all taken in traps set at ground level. It glides from one tree to another with legs and patagium extended, giving it a ghost-like appearance in the dim night light. The flying squirrel is omnivorous, and possibly takes more animal foods than its larger counterparts: insects, snails and other small invertebrates, bird eggs and nestlings, as well as seeds, berries, nuts (particularly acorns and hickory nuts), fruits, blossoms, fungi, lichens, and bark (Conner 1960, Dolan and Carter 1977, Muul 1968, Stoddard 1920, Ernst pers.

obs.). Some foods may be stored in tree holes (Ernst pers. obs.).

Two litters of 3-4 (2-7) young are born each year in April or May and August or September after a gestation period of about 40 days (Hibbard 1935, Uhlig 1956), and we have found lactating females during both these periods in Fairfax County.

Owls are probably the chief predator, but black rat snakes (*Elaphe obsoleta*) often forage in hollow trees eating some (Ernst pers. obs.), and domestic cats catch them on the ground (Hamilton 1963).

***Marmota monax* (Woodchuck).** Because the woodchuck spends most its time on or under the ground it is often not considered a squirrel; nevertheless, it is the largest one of the region. Its body is reddish to grayish-brown with dark brown or black feet, some white around the nose, and a relatively short, dark, bushy tail. The ears are short and round, and the toes have heavy claws. External measurements of four individuals from northern Virginia in the GMU collection are TBL 62.5 cm (50.0-75.0), TL 20.7 cm (19.5-23.5), and HFL 8.3 cm (8.1-8.8). The dental formula is i 1/1, c 0/0, pm 2/1, m 3/3 x 2 = 22. The subspecies in northern Virginia is *Marmota monax monax* (Hall 1981).

The woodchuck prefers to dig its burrow in the transition zone between woods and open spaces, on the borders of fields, or in clay banks; it is much less common in deep woods. At Fort Belvoir some have invaded the developed areas where they can be seen grazing on lawns and golf courses. We have trapped or observed them at sites 5, 6, 9, 10, 12-14, 203, 205; at two sites along the lower flood plain of Accotink Creek; at one site along Pohick Creek; at culverts 9402, 9405, 9406, and 9409; and at the Accotink Bay Wildlife Refuge. Two specimens from Fort Belvoir are in the USNM (349710-349711). *Marmota* is one of the most frequently killed mammals on the installations roads; DOR records exist for Backlick Road, Beulah Road, and U.S. Rt. 1.

The woodchuck is most active in the early morning and late afternoon, and hibernates from mid-November to March in its burrow. It is a true hibernator; its body functions slowing and its temperature dropping, causing it to become torpid. The same burrow is used as a retreat during the active months, and can be as long as 9 m and dug as deep as 1.5 m with 2-3 entrances (Barbour and Davis 1974). Most entrances have an associated dirt mound. The burrow contains an enlarged chamber near its end with a grass nest that is used for hibernating, sleeping or housing the young.

Three to five blind, helpless young are born in April after a gestation period of 3-4 weeks. The young usually do not make their appearance above ground until mid- to late May.

Woodchucks feed almost exclusively on grasses, sedges, and clover, but do not hesitate to raid vegetable gardens or flower beds. Besides humans, only packs of feral dogs and bobcats are predators in northern Virginia. When disturbed *Marmota* will raise up on its hind feet, and, if further threatened, immediately run to its burrow. It is a good climber, and sometimes ascends a tree if prevented from reaching its burrow. It is fierce when cornered, and its large incisors can inflict a severe bite.

***Sciurus carolinensis* (Gray Squirrel).** The common diurnal tree squirrel of the region, this rodent has the top and sides of its head and body a grizzled gray. Its bushy, flattened tail has a white border, and the venter and back of the ears are white. The feet and hips are cinnamon-colored. Occasionally a melanistic (black) individual is seen in northern Virginia, and in 1991 an albino (white) *Sciurus carolinensis* was present on the George Mason University campus. External measurements of 21 adults from northern Virginia in the GMU collection are TBL 44.1 cm (37.7-53.0), TL 20.5 cm (15.0-29.0), and HFL 6.0 cm (5.2-7.0). The dental formula is i 1/1, c 0/0, pm 2/1, m 3/3 x 2 = 22; the first upper premolar is a small peg. The subspecies in northern Virginia is *Sciurus carolinensis pennsylvanicus* (Koprowski 1994).

The gray squirrel is found in a variety of arboreal habitats ranging from dense hardwood forests to mixed forests or even small stands of pines. It has adapted well to an association with humans, and flourishes in northern Virginia's cities and suburbs; it is quite common in the scattered trees about the buildings and residents on Fort Belvoir. Kelso (1992) reported that it has increased in numbers in the region. We have only trapped four at sites 9, 201 and 202, but have observed it near all the other trap sites, culvert sites 9405-9407, 9409-10, and 9414, at both the Jackson Abbott Wetland Refuge and Accotink Bay Wildlife Refuge, along the flood plains of all three major creeks flowing through the installation, and on both golf courses. This is the most frequently road-killed mammal in northern Virginia, and DOR individuals have been recorded from all of Fort Belvoir's major roads. Four specimens from Fort Belvoir are in the USNM collection (349708-09, 512051-52).

Sciurus carolinensis is active in every month, but remains in its bulky, leaf-ball nest or in a tree hole during bad weather. At such times they are quite communal. Two breeding periods occur each year, in December to February and again in May and June (Brauer and Dusing 1961, Brown and Yeager 1945). After a gestation period of about 44 days (Webley and Johnson 1983), 2-3 (2-5) naked, blind young are born in a leaf nest or tree hole in late winter or early spring or midsummer (Paradiso 1969). Weaning is completed in 10 weeks; population densities are very high at these times and roadkills increase dramatically. The gray squirrel shows little territoriality.

Most are familiar with the gray squirrel's habit of burying nuts for later use, and nuts, flowers, buds and fruits make up the bulk of the diet (Koprowski 1994, Paradiso 1969). It will also eat fungi, raid bird nests for eggs and nestlings (Paradiso 1969), as well as eat carrion, especially its DOR compatriots.

The automobile seems to be the worst enemy of the gray squirrel in northern Virginia, but climbing black rat snakes (*Elaphe obsoleta*), large hawks and owls, and domestic cats catch a few.

Formerly the fox squirrel (*Sciurus niger)* also occurred in Fairfax County. It was last collected in 1973 (Ernst 1994), but has been observed in a Vienna subdivision in 1994 (Boucher pers. obs.). A male and three female fox squirrels (USNM 101581-101584) were taken at Accotink, 8 January 1900, so this species may have once occurred at Fort Belvoir.

***Tamias striatus* (Eastern Chipmunk).** The chipmunk is the smallest of the two ground squirrels at Fort Belvoir, the other being the much larger woodchuck (*Marmota monax*). *Tamias* has a distinct black-bordered, cream-colored stripe on each side of the back which extends to the base of the rump, but not onto it. The top of the head, sides, upper legs, and rump are reddish in color. The venter is yellowish-brown, and the feet are yellowish. The tail is dorsoventrally flattened with some black or dark grey hairs. Two cream-colored stripes occur on each side of the face, one above and one below the black, prominent eye. Internal cheek pouches are present in which seeds are transported back to the burrow for storage. External measurements of 17 northern Virginia adults in the GMU collection are TBL 226.1 mm (190.0-250.0), TL 82.3 mm (72.0-95.0), and HFL 31.1 mm (23.0-35.0). The dental formula is i 1/1, c 0/0, pm 1/1, m 3/3 x 2 = 20. The subspecies in northern Virginia is *Tamias striatus fisheri* (Snyder, 1982).

Generally a resident of woodlands (both hardwood and coniferous), The chipmunk also occurs in bushy old fields and even among the shrubs about buildings at Fort Belvoir. It lives in an underground den, usually among tree or shrub roots (Ernst and Ernst 1972), which it digs itself to depths near 1 m in northern Virginia. Within this burrow are an enlarged, leaf-lined nest chamber and one or more smaller storage chambers for seeds, nuts and fruits. It is surface active in every month in Fairfax County, but less so in the winter when it may only come out of the ground on warm, sunny days. It seems totally diurnal. Foraging activity is not confined to the ground, however, and when spring buds are on shrubs and small trees Fort Belvoir chipmunks may ascend to 3 m to feed on them.

Because of their good jumping ability none were caught in pitfall traps, but 19 were captured in live traps at sites 201, 203, 205, 207; culvert sites 9403, 9405, 9407-9410, 9414; and at one site on the lower flood plain of Pohick Creek.

Tamias striatus has two breeding periods in northern Virginia: from late February to early April and again in late June and early July (Elliott 1978, Smith and Smith 1972). Males are very aggressive at these times and apparently a type of dominance system is established. The gestation period is about 32 days (Allen 1938), and helpless young are born in the underground nest in April or May and again in July or early August. The average litter size is 4-5 young (3-5) (Allen 1938; Paradiso, 1969), but a nest excavated in Fairfax County by Ernst on 18 April, 1975 had six blind, naked young.

The food consists mostly of buds, seeds, berries, fruits, and nuts, and occasionally slugs, snails, insects, small snakes, small birds and mice (Elliott 1978, Paradiso 1969, Snyder 1982). Chipmunks will feed on DOR carrion, even of their own species (Ernst pers. obs.).

From our experience, snakes (*Elaphe*, *Coluber*), large hawks and domestic cats seem to be the major predators on chipmunks in Fairfax County, but weasels, foxes, feral dogs, and bobcats also prey on them (Snyder 1982).

Family Dipodidae (Jumping Mice)

***Zapus hudsonius* (Meadow Jumping Mouse).** This mouse is easily identified by its long tail, large hind feet, yellowish sides, and darker grayish-brown back. The venter, front feet, and hind feet are white. External measurements of 12 adults from Fort Belvoir are TBL 2173.9 mm (158.0-202.0), TL 106.1 mm (95.0-125.0), and HFL 22.6 mm (17.5-30.0). The dental formula is i 1/1, c 0/0, pm 1/0, m 3/3 x 2 = 18; this is the only Fort Belvoir rodent with a groove on the front surface of its upper incisors. The subspecies in northern Virginia is *Zapus hudsonius pallidus* (Whitaker 1972a).

The meadow jumping mouse is rather habitat specific at Fort Belvoir, being found mainly in thick vegetation, often bramble thickets, along waterways. Only 13 have been captured, although several others have been seen, at trapping sites 5, 7, 201-207, CA and CG.

Zapus hudsonius has the shortest annual activity period (six months) of any rodent at Fort Belvoir. In the vicinity of Washington, D. C., it is normally active from early April until early October, although a few have been taken as late as November or as early as February (Paradiso 1969). We have only trapped or observed this mouse in May, June and August at Fort Belvoir. *Zapus* is a true hibernator, entering a leaf-lined burrow chamber about 60 cm under the ground or a larger mammal's burrow as deep as 1.2 m (Paradiso 1969) and becoming totally torpid during the winter. It is active both day and night but is chiefly nocturnal at Fort Belvoir. When foraging, it usually creeps along on all four legs, but if disturbed bounds away on its hind legs like a little kangaroo, thus its common name "jumping" mouse.

Most reproduction occurs in May and June, and probably two litters are produced each year. Ernst has found lactating females in both May and June at the nearby Mason Neck National Wildlife Refuge. The gestation period lasts 17-21 days, and litters typically have 5 young (3-8) (Krutzch 1954, Quimby 1951, Whitaker 1963).

The meadow jumping mouse is omnivorous, and although seeds, berries, and nuts of various plants are preferred, fungi, and some insects are also eaten (Quimby 1951, Whitaker 1963). Various snakes, especially the black rat snake (*Elaphe obsoleta*) hawks, owls, mink, skunks, weasels, cats, dogs, and foxes prey on this mouse (Barbour and Davis 1974; Whitaker 1963, 1972a; Ernst pers. obs.).

Carnivora (Carnivores)

Family Canidae (Dogs, Foxes)

***Urocyon cinereoargenteus* (Gray Fox).** The back and sides of this fox are gray with a mixture of black and white-tipped hairs, and a series of black-tipped hairs forms a dark stripe on the back. The bushy tail is black-tipped, and the snout also has some black pigmentation. Cinnamon-colored hairs are present on the neck, sides, and short legs; the venter is white to yellowish-gray. External measurements of five adults from northern Virginia in the GMU collection are TBL 69.8 cm (54.0-90.0), TL 35.8 cm (30.2-39.0), and HFL 12.9 cm (12.5-13.0). The dental formula is i 3/3, c 1/1, pm 4/4, m 2/3 x 2 = 42. The subspecies in northern Virginia is *Urocyon cinereoargenteus cinereoargenteus* (Hall, 1981).

We have seen little of this species at Fort Belvoir, but it is present, in bushy, deciduous woods. It is a good climber; we have seen it ascend a tree trunk leaning at a 45 degree angle. The numbers of gray foxes do not appear to be great, as its presence at Fort Belvoir is based only on observations or tracks found at culvert sites 9409 and 9410, two sites along Accotink Creek, and another on the flood plain of Pohick Creek.

Mating takes place from January to May in New York, with a peak in March (Layne and McKeon, 1956; Sheldon, 1949), and northern Virginia gray foxes probably follow a similar cycle. The gestation period is probably between 53-63 days (Fritzell and Haroldson 1982), and we have found a den with four pups at the nearby Mason Neck National Wildlife Refuge on 15 May. Litters may contain 1-10 pups, but 3-4 is normal (Layne and McKeon 1956, Sheldon 1949).

Diet consists mostly of shrews, mice, chipmunks, and cottontail rabbits, but crickets, grasshoppers, lizards, snakes, birds, and various fruits are also taken (Fritzell and Haroldson 1982, Nelson 1933, Paradiso 1969, Trapp and Hallberg 1975). Llewlyn and Uhler (1952) reported that animal foods make up to 70 percent of the gray fox's prey, while plants form the other 30 percent.

Humans with their traps, guns, automobiles, and habitat destruction are the worst enemy of *Urocyon*, but bobcats and large domestic dogs also kill them.

***Vulpes vulpes* (Red Fox).** The red fox is appropriately named for the rusty-red fur on its face, back, sides and tail. This fur is often mixed with white, and the cheeks, throat, chest and venter are also white. The bushy tail is mixed with white and black and has a white tip. The feet and back of the ears are black. *Vulpes* is about the size of a small dog; average external measurements of four adults from northern Virginia in the GMU collection are TBL 100.1 cm (92.0-107.0), TL 36.9 cm (34.0-38.0), and HFL 13.1 cm (8.0-15.5). The dental formula is i 3/3, c 1/1, pm 4/4, m 3/3 x 2 = 42. The subspecies in northern Virginia is *Vulpes vulpes fulva* (Hall 1981)

The red fox is common in sparsely wooded areas and around old fields at Fort Belvoir. We have not trapped it, but have seen it or its tracks at trap site 1 and culverts 9404, 9409, 9410, and 9414. Roadkills have also been recorded from Backlick, Lorton and Poe roads, and U.S. Rt. 1. The mammal collection at the USNM has two specimens from Fort Belvoir (349914, 513417).

We have gathered no life history data on this species, but in Maryland it mates in January or February, and, after a gestation period of 49-53 days, delivers a single litter of 4-5 (1-13) pups (Ables 1975, Paradiso 1969). *Vulpes* is thought to be monogamous, with both parents providing food and caring for the pups. The pups are born blind and helpless in a den which also serves as the family quarters of the adults. Although the red fox can excavate its own burrow, most often it just widens one previously dug by a woodchuck. Although active at any time of the day, it is most often seen at dusk

or in the early morning. It is usually considered a carnivore, but is really an omnivore, eating up to 17% plant foods (Llewelyn and Uhler 1952, Scott 1947, Stanley 1963). Principal animal prey includes insects, turtles, small birds, shrews, moles, mice, chipmunks, and cottontails (30-40% of its animal food). Most plant material is eaten from November through January: fruits (particularly persimmons), berries (wild grapes, pokeberry). Other than humans with their motorized vehicles, the only enemies at Fort Belvoir are feral dog packs and bobcats.

***Canis familiaris* (Common Dog).** Common dogs are also present at Fort Belvoir. Most are pets allowed to roam free by their owners, but some may live in a feral state. The dog needs no description, except its dental formula: i 3/3, c 1/1, pm 4/4, m 2/3 x 2 = 42. We have recorded it from pitfall trap sites 2-4, 7-8, 14; culvert sites 9404-9406, 9409-9410;, the Jackson Abbott Wetland Refuge; the Accotink Bay Wildlife Refuge; the floodplain of Pohick Creek; and as roadkills on Backlick, Beulah, and Telegraph roads and U.S. Rt. 1.

Free roaming dogs may pose a hazard to amphibians, reptiles, birds, and small mammals on the installation, and, if they form packs, may even kill deer (Federoff et al. 1994). Domestic pets should only be allowed access to wild areas if leashed, and feral dogs should be eliminated!

Family Felidae (Cats)

***Lynx rufus* (Bobcat).** Not many persons realize that a few bobcats still reside in Fairfax County; unfortunately, the species is declining in the region (Kelso 1992). The bobcat is the largest mammalian predator at Fort Belvoir. It is at least twice the size and weight of the a big domestic cat (*Felis cati)*; has long legs and large feet, which give the appearance of walking on stilts; a short tail; and large ears. The fur on the back and sides is grayish-brown and darker along the midline of the back; some dark spots are usually present. The venter is white to gray with scattered dark spots. The tail is usually black-tipped. The back of the ears are patterned with alternating black and white bars, and the tip of the ear has a short hair tuft. A female from Fauquir County in the GMU collection has the following external measurements: TBL 85 cm, TL 12 cm, and HFL 16.3 cm. The dental formula is i 3/3, c 1/1, pm 2/2, m 1/1 x 2 = 28. The subspecies in northern Virginia is *Lynx rufus rufus* (Hall 1981).

We have only encountered *Lynx rufus*, or it's sign, in thick, wet woodlands at Fort Belvoir or at the nearby Mason Neck National Wildlife Refuge. The bobcat's home range can be large, "as small as 5 miles, or as much as 50 miles" in diameter (Young 1958, see also Bailey 1974), so the same bobcats may be using both Fort Belvoir and the Mason Neck refuge. In addition it often follows moving deer herds. Bobcats tend to establish home ranges away from primary and secondary highways, but will cross secondary roads, unpaved roads, and trails within their home range (Lovallo and Anderson 1996), such as occur in the wildlife corridor at Fort Belvoir. Fort Belvoir records are all of tracks: trap site 206, culvert sites 9405 and 9412, and on the unopened section of the Fairfax County Parkway approximately 300 m west of U.S. Rt 1. The latter record, a set of tracks found 31 May 1996, indicated the bobcat was chasing a deer fawn along the side of the road.

Lynx rufus is almost entirely nocturnal and thus seldom seen. During the day it sleeps in a permanent den, usually a hollow tree, log or stump. The bobcat is active all year, and, except in the mating season, is usually a solitary forager. It seems to be a strict carnivore, and, because of its size and strength, can feed on any other vertebrate at Fort Belvoir, including deer (particularly fawns) which are a favorite prey. However, squirrels, chipmunks, mice, muskrats, and birds probably make up most of the diet (Paradiso 1969, Young 1958).

Other than humans, it has no predators at Fort Belvoir.

Mating occurs most often in the late winter or early spring, but ranges from November to

August (Fritts and Sealander 1978). At such times bobcat screams may be quite loud. Ernst has heard what he interpreted as courtship and mating vocalizations in late September, and some autumn pregnancies have been recorded (Banfield 1974, Young 1958). After a gestation period of about 60-70 days (Hemmer 1976), a single litter of 1-4 kittens is born in late April or early May (Banfield 1974, Paradiso 1969, Young 1958). The blind, helpless young take about 60-70 days to be weaned to meat, and, as with other cats, are cared for and taught hunting behavior and prey selection entirely by the female (Young 1958).

***Felis cati* (Common Cat).** Domestic cats are also present at Fort Belvoir. Some are feral, but we believe most are pets allowed to roam the installation by their owners. This animal is familiar enough that no detailed description is needed, but its dental formula differs from that of the much larger bobcat (see above) in normally having two more premolars: i 3/3, c 1/1, pm 3/2, m 1/1 x 2 = 30. Our records for the common cat include sightings about various residences and buildings; pitfall trap sites 1-5, 9, 12-14, 201-203, 206; culvert sites 9404-9406, 9409-9410; the Accotink Bay Wildlife Refuge; a site on the lower floodplain of Accotink Creek; and roadkills on Backlick and Telegraph roads and U.S. Rt. 1.

Felis cati is an adept hunter of small vertebrates, and it can cause serious damage to the populations of small breeding birds, mice, chipmunks, shrews, amphibians and small reptiles.

Family Mustelidae (Mustelids)

***Lontra canadensis* (River Otter).** The aquatic river otter, a member of the family generally referred to as weasels, is the largest mustelid in the region. Its thick fur is dark brown while the undersides are lighter and the throat and chin are silverish-gray to yellowish-brown. The legs are short with webbed toes, and the tail is long, thick and tapering. The head appears small for such a long body with a short, broad snout, short ears, and long whiskers. We have measured no otter from northern Virginia, but typical external measurements from Hamilton (1963) are TBL 90-110 cm, TL 30-40 cm, and HFL 10 cm. The dental formula is i 3/3, c 1/1, pm 4/3, m 1/2 x 2 = 36. The subspecies in northern Virginia is *Lontra canadensis lataxina* (Hall, 1981).

The river otter inhabits the streams and marshes adjacent to the Potomac River, and is declining in the region (Kelso 1992). It is so seldom seen that few people know it still exists in the region, although there are a few sightings of it each year along the Potomac River from Great Falls to Quantico. In the spring of 1986 Steve W. Gotte (pers. com.) observed an otter downstream from the water treatment plant on Pohick Creek at Fort Belvoir, and on 17 April, 1995 Ernst found otter scat at the Jackson Abbott Wetland Refuge on Dogue Creek. Previously, Steven W. Sekscinski (pers. com.) had found piles of crayfish remains at the Abbott Refuge which he attributed to an otter. Formerly scat of this species was frequently found on the observation boardwalk and the river otter was occasionally seen at Huntley Meadows Park upstream from Fort Belvoir on Dogue Creek. It is still sometimes seen in the Great Marsh at the Mason Neck National Wildlife Refuge, downstream from Fort Belvoir on the Potomac River (Steve W. Gotte pers. com., Ernst pers. obs.). *Lontra* is more often nocturnal, but is also active during daylight hours.

It is active in every month, and usually lives in a burrow in the bank of a stream, although it sometimes uses an abandoned beaver lodge (Paradiso 1969).

Other than a few sightings, we have recorded no life history data. It is a powerful swimmer that feeds primarily on fish, but it will also take crayfish, frogs, turtles, aquatic birds, and even muskrats (Liers 1951). Breeding probably takes place in late winter or early spring. The gestation period is as long as 9-12 months (most of which is due to delayed implantation of the fetus), and only one litter of about 2-4 kits is born each year, usually in the spring (Liers 1951, Nowak 1991). Other than humans,

and possibly bobcats, the river otter has no enemies in northern Virginia.

Mephitis mephitis **(Striped Skunk).** The physical and descriptive attributes of the stripped skunk are familier to most people. Its coarse body hair is black except for a white streak extending from the forehead to the nose, a rounded white patch on the back of the head and nape from which two lateral stripes of varying width extend to the rump, and some long white hairs on the bushy tail. The snout is pointed, the ears are small and round, and the eyes black. The legs are short and the claws on both feet are thick; the hindfeet are plantigrade with the entire bottom from toe to heel pressed onto the ground. External measurements of two adults from northern Virginia in the GMU collection are TBL 467.5 mm (410.0-525.0), TL 232.5 mm (215.0-250.0), and HFL 63.0 mm (37.0-69.0). The dental formula is i 3/3, c 1/1, pm 3/3, m 1/2 x 2 = 34. The subspecies in northern Virginia is *Mephitis mephitis nigra* (Hall 1981).

The black and white coloration serves as a warning that this animal can retaliate with a very foul-smelling discharge of methyl mercaptane from its anal glands. When agitated the striped skunk snorts, stamps his forefeet, raises its tail, and bends its body so that its anal vent and eyes are both facing the intruder (Ernst 1965). If the intruder does not retreat, the skunk sprays it with a malodorous "perfume". Would be predators and people soon get the message!

Predators, other than humans, in northern Virginia include great-horned owls, bald eagles, foxes, feral dogs, and bobcats.

The breeding season encompasses late February and March in Fairfax County, and males become very aggressive during this period (Ernst 1965). Gestation usually takes 60-62 days, and a single litter of 4-6 (2-10) young are born in May (Paradiso 1969, Verts 1967, Wade-Smith 1978, Ernst pers. obs.). After the young are weaned, they often can be seen accompanying their mother on twilight foraging trips.

The skunk is primarily nocturnal and may be about in every month. It is more lethargic in winter and may enter some degree of torpor (Banfield 1974, Sunquist 1974). During bad weather it tends to remain in a leafy nest inside of a burrow it has excavated, or in a woodchuck burrow, hollow log or stump, storm sewer, or hole beneath some building. It uses this same hiding place as a daytime retreat during the rest of the year. More are seen alive or found DOR from March to August in Fairfax County.

The striped skunk is omnivorous with insects (especially beetles) forming the bulk (almost 50%) of its diet, but various small vertebrates (frogs, lizards, snakes, turtle eggs, moles, shrews, mice) are also taken, and it will eat vegetation, particularly in summer (Paradiso 1969, Shaw 1928, Verts 1967, Wade-Smith and Verts 1982). Ernst has seen a skunk scavenge a DOR gray squirrel.

It is most often seen along the edge of a hardwood or mixed woods or in a shrubby old field, but at Fort Belvoir it is equally at home in barracks and residential areas. It has been recorded at culvert sites 9413-14, and DOR skunks have been found on U.S. Rt. 1 and Backlick, Beulah and Poe roads. Kelso (1992) has reported that populations of this animal are declining in Fairfax County.

Mustela vison **(Mink).** The mink distinctly prefers streamside habitats, and it was only in such habitats that we recorded it at Fort Belvoir: three sites on the flood plain of Accotink Creek, one on the flood plain of Pohick Creek, the Accotink Bay Wildlife Refuge, the Jackson Abbott Wetland Refuge, and pitfall trap site 5.

The thick, commercially valuable fur of mink is dark glossy brown. The only white is restricted

to a patch of hairs on the chin (sometimes extending to the upper throat) and a few scattered spots along the venter; the less white, the more valuable the pelt. The dark tipped tail is slightly bushy, and the feet are often dark. The snout and ears are short. Average external measurements of six northern Virginia specimens in the GMU collection are TBL 50.4 cm (24.0-63.0), TL 18.8 cm (15.0-25.0), and HFL 5.8 cm (4.0-6.7). The dental formula is i 3/3, c 1/1, pm 3/3, m 1/2 x 2 = 34. The subspecies in northern Virginia is *Mustela vison mink* (Hall 1981).

The mink is active all year. It is most often encountered at night, at dusk, or dawn. It lives adjacent to water in a bank burrow under overhanging tree roots, often one abandoned by muskrats; in hollow logs or stumps; or occasionally in muskrat or beaver lodges.

In the Mid-Atlantic Region the mating season extends from January through March, with the young appearing in April and May (Ernst pers. obs.). Typical litters have 3-6(3-10) naked, blind, helpless kits. The kits are weaned after about six weeks and both parents help rear the young. After the young are feeding own their own, male mink assume a solitary life style while the kits remain with the female until the fall (Ernst pers. obs.).

The mink is an opportunistic carnivore that will eat almost any animal in encounters. It is a good swimmer and will forage for fish and crayfish in shallow water (Ernst pers. obs.), but most prey is vertebrate: frogs, turtles, small snakes, small birds, shrews, moles, small rabbits, mice, rats, and muskrats (Barbour and Davis 1974; Hamilton 1936a, 1940b; Llewellyn and Uhler 1952; Paradiso 1969; Ernst pers. obs.). Winter prey is almost entirely mice and muskrats.

Besides trapping and vehicular deaths attributable to humans, larger carnivorous mammals (foxes, dogs, cats, bobcats), owls, and black rat snakes (*Elaphe obsoleta*) are potential predators of Fort Belvoir's minks.

Two other weasels reported from Fairfax County, but not detected in our studies, may occur on the installation. The long-tailed weasel (*Mustela frenata*) has been collected nearby at Alexandria (USNM 236646, 241496, 254533, 254589), and we expect that some live on the installation. More problematic is the possible presence of the European ferret or polecat (*Mustela putorius*), which has been introduced into the United States by the pet trade. The several DOR specimens recorded from Fairfax County have been either escaped or released pets. One (GMU 1213) was collected on Gunston Road near the entrance of the Pohick Bay Regional Park adjacent to Fort Belvoir. It is possible that an escaped pregnant female ferret could establish a colony at Fort Belvoir to the detriment of its small vertebrate fauna.

Family Procyonidae (Procyonids)

***Procyon lotor* (Raccoon).** Our observations at Fort Belvoir indicate that the raccoon is the regions most common carnivore. It is best recognized by its black mask and dark-ringed tail (not all individuals are so marked, but, normally, at least one of these two characters is present). The fur is grayish-brown. The feet are lighter than the back or sides, and the raccoon walks plantigrade (flat-footed). External measurements of five adults from northern Virginia in the GMU collection are TBL 64.1 cm (50.0-72.4), TL 22.6 cm (21.0-26.7), and HFL 10.0 cm (8.9-10.8). The dental formula is i 3/3, c 1/1, pm 4/4, m 2/2 x 2 = 40; the fourth upper premolar and the upper molars are somewhat flat-crowned with the cutting surfaces at the sides. The subspecies in northern Virginia is *Procyon lotor lotor* (Hall 1981).

The raccoon is a generalist. It can be found in any season, although it is less active in the winter when it lives off fat reserves and can loose 50% of its body weight (Lotze and Anderson 1979), and in any habitat where trees are present. It is nocturnal and spends the day in an underground burrow (usually appropriated from some other mammal), storm sewer, under an outbuilding, in a hollow log

or stump, in a tree hole, or even in old muskrat lodges (Urban 1970). It is good climber. We have even seen raccoons sleeping in the crotch of a tree or flattened-out on a limb at Fort Belvoir. We have only trapped it at sites 202 and 204-206, but have seen it or its tracks at every trapping station, all culvert sites, on the flood plains of all three major creeks flowing through the installation, and at both the Jackson Abbott Wetland Refuge and the Accotink Bay Wildlife Refuge.

Procyon lotor is one of the most frequently killed mammals on Fort Belvoir's roads, especially U.S. Rt. 1 and Backlick and Beulah roads. Kelso (1992) reported populations increasing in the region which may, in part, explain why more are observed DOR.

The reproductive season begins in January and February, but most mating probably occurs in March in northern Virginia; 3-6 helpless young are born about 63 days later (Paradiso 1969). Weaning takes about 60 days.

The raccoon is omnivorous, eating freshwater mussels, crayfish, insects, frogs, salamanders, lizards, small snakes, mice, small birds and their eggs and nestlings, nuts, and fruits (Hamilton 1936b, 1940b; Lotze and Anderson 1979). We have found DOR raccoons with their stomachs packed with corn or grasshoppers, and have found evidence of one eating freshwater mussels on the floodplain of Accotink Creek. *Procyon* has become a nuisance in residential areas by scavenging in garbage and trash cans.

Other than humans, the raccoon has few enemies in northern Virginia, but feral dogs and bobcats will attack them. The rabies epidemic of the late 1980s and early 1990s in Virginia and Maryland was essentially a raccoon epidemic.

Artiodactyla (Even-toed Ungulates)

Family Cervidae (Deer)

***Odocoileus virginianus* (White-tailed Deer).** The white-tailed deer is the only large wild herbivore inhabiting northern Virginia. At Fort Belvoir, it has been seen, or its tracks found, at every trapping and culvert site, at both the Accotink Bay Wildlife Refuge and the Jackson Abbott Wetland Refuge, along the lower floodplains of Accotink, Dogue, and Pohick creeks, on the fairways of the golf courses, and on some lawns and old fields. In addition, the annual deer hunt on the installation yielded 37 (26 bucks, 11 does) in 1984/1985, 50 (34 bucks, 16 does) in 1985/1986, 43 in 1986/1987 (26, 17), 96 in 1987/1988 (43, 53), 105 in 1988/1989 (62,43), 139 in 1989/1990 (101, 38), 74 in 1990/1991 (44, 30), 144 in 1993/1994 (76, 68), 179 in 1994/1995 (90, 89), and 190 in 1995/1996 (91, 99). Records were not available for the 1992/1993 and 1993/1994 hunts. Increases in numbers may indicate a growing deer herd on the installation, but may also reflect increases in the length of the hunting period). Many DOR deer have been recorded on the roads traversing Fort Belvoir, particularly U.S. Rt. 1 and Backlick Road, each year since 1988. The population in northern Virginia seems to be increasing, but this may be a false impression as suitable second growth woodlands are disappearing at an alarming rate in the region. The deer, being forced into smaller areas, encounter humans more often.

Summer pelage is tan to reddish-brown, winter coat color is more grayish-brown. Fawns are reddish-brown with white dorsal spots. The venter is always white. Adults have a white transverse bar on the snout, a white eye ring, and a dark spot on the sides of each lower lip. The underside of the tail is white, and, when alarmed and bounding away, the deer will raise the tail to display this white "flag" as a warning to other nearby deer. No northern Virginia *Odocoileus* was measured, but external measurements for males listed by Smith (1991) are TBL 104.1-240.0 cm, TL 10.0-36.5 cm, HFL 27.9-53.8 cm, and height at shoulder 53.3-106.7 cm. Females are smaller than males. Dressed weights were recorded for 190 deer taken during the 1995/1996 hunt at Fort Belvoir; 34 of 91 males weighed over

45.35 kg (100 lbs) with a top weight of 72.56 kg (160 lbs, two bucks), while only four of 99 females weighed over 45.35 kg with a top weight of 49.89 kg (110 lbs, two does). Antlers are restricted to males, and are usually branched after the first year (spike buck stage). The antlers never have branches growing from branches, and the size and shape are largely a function of age and nutrition. The hoof is cloven, and the tracks resemble a narrow split heart (see Murie 1974). The dental formula is i 0/3, c 0/1, pm 3/3, m 3/3 x 2 = 32. The subspecies in northern Virginia is the nominate race, *Odocoileus virginianus virginianus* (Smith 1991).

The rutting period is in the fall, with mating usually in November in this region. Males are fully antlered at this time (antlers are shed after the rutting season) and defend a harem of several females against other males. Ernst has seen a large buck at the nearby Mason Neck National Wildlife Refuge with a harem of 12 females, but usually the females in a harem total less than three. The speckled fawns are born in May (usually only one, but sometimes two in northern Virginia), and can often be found hidden in old fields where the female has left them while she forages.

Seven deer were sacrificed during a health check 6 March 1995 (two bucks, five does). All appeared in good condition with good fat content, possibly due to the mild weather and abundance of acorns the previous winter. The does averaged 3.5 years of age and 299.8 kg (136 lbs) live weight. All five does were pregnant, although only four were lactating. Conception dates were estimated to have been 1-27 November 1994. The average number of fetuses per female was 1.8, with only one doe containing less than two fetuses (a single male). Six fetuses were males and three were females. Three of the four does with two fetuses had fraternal twins; the single set of identical twins was male.

Odocoileus is predominately a browser, feeding on the fruits and tender parts of apple, beech, chokeberry, wild grape, greenbrier, hawthorn, maple, persimmon, sumac, viburnum, cedar and other conifers (Hamilton 1963, Smith 1991, Ernst pers. obs.). Browsing in concentrated areas has resulted in a serious loss of understory plants in northern Virginia. Deer may also harm gardens and some agricultural crops. In the fall and winter, acorns seem the preferred food. If the acorn crop is light, they will graze on grasses, sedges, mushrooms, or even eat dried leaves during the winter. Humans, by habitat destruction, vehicles and guns, are the deer's worst enemy, but feral packs of dogs (Federoff et al. 1994, Ernst pers. obs.) at Mason Neck National Wildlife Refuge, and possibly the bobcat at Fort Belvoir, may take a few.

Acknowledgements

The authors thank Scott C. Belfit, Dorothy Keogh, Mike Hudson and Steven W. Sekscienski for providing collecting permits and logistical help during the course of the study. Jeremy Jacobs provided data on mammals from Fort Belvoir and northern Virginia in the collection of the USNM. John R. Wilder and James C. Wilgenbusch prepared the figures, and the following persons helped with field collections over the years: Thomas Akre, Cynthia L. Beck, Mary Cogliano, Stephen L. Copps, Sandra E. D'Alessandro, Steve W. Gotte, Douglas A. Holliday, Maureen E. Kearney, Peter J. King, Thomas E. Leuteritz, John F. McBreen, Steven W. Sekscienski, Allison M. Sinclair, Shiela Tuttle, John R. Wilder, James C. Wilgenbusch, and Thomas P. Wilson.

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A Small Mammal Survey of the Patuxent River Naval Air Station, Including the First Records for the Southeastern Shrew (*Sorex longirostris*) and Masked Shrew (*Sorex cinereus*) from St. Mary's County, Maryland

Kyle Rambo

Pitfall trapping conducted at the Patuxent River Naval Air Station (PRNAS) in St. Mary's County, Maryland during the summer of 1994 produced records for six species of small mammals. Specimens collected included both the Southeastern shrew (*Sorex longirostris longirostris* Bachman) and Masked shrew (*Sorex cinereus fontinalis* Hollister), providing the first records for these two species from Saint Mary's County, Maryland.

Thirty pitfall arrays (pitfall traps in triad arrangement with drift fences) were placed in several different habitats of varying patch size in an effort to document the occurrence and relative abundance of small mammals, as well as the potential influence of patch size on species composition and abundance. Pitfalls were also placed at interior and edge sites within each patch to assess the possible impact of edge proximity. Thirty-five days of trapping produced only 11 specimens of six small mammal species. Extremely low catch rates during the sampling period (July and August) may have been due to drought and high temperatures, which may have limited mammal activity. While catch rates were too low to yield useful information regarding relative abundance or the impact of patch size and edge, the survey did reveal the presence of the two shrews whose occurrence had not been documented for St. Mary's County. The other four species captured were White-footed mouse (*Peromyscus leucopus*), Pine vole (*Pitymys pinetorum*), Short-tailed shrew (*Blarina brevicauda*) and Meadow vole (*Microtus pennsylvanicus*). Specimens of each of these mammal species are preserved and archived in the permanent Navy collection at PRNAS.

A single specimen of *S. l. longirostris* was captured on August 15, 1994 at the interior array of a large deciduous forest patch. A single specimen of *S. c. fontinalis* was also captured on August 15, 1994 at the edge array of another large forest patch. These two species are very similar in appearance and can be difficult to separate. They were identified on the basis of dentition as described by Paradiso (1969), as well as the pelage characteristics and skull measurements given by French (1980).

Paradiso (1969) described the range of *S. c. fontinalis* in Maryland as the Piedmont, Western Shore, and Eastern Shore sections. He recorded specimens for Baltimore, Montgomery, Prince George's and Anne Arundel Counties. Another subspecies, *Sorex cinereus cinereus*, has a more northerly distribution, with specimens recorded in Allegany and Garrett Counties.

Paradiso (1969) gave the range of *S l. longirostris* in Maryland as the southern portion of the Western Shore section, and perhaps extending into the lower Piedmont section. Maryland is the northernmost limit of the distribution of the species in the eastern United States (Paradiso 1969, Hall 1981). Paradiso gave Maryland records from Calvert, Anne Arundel, and Prince George's Counties, as well as the District of Columbia. There are also several records for this small shrew from Montgomery County, Maryland. Hall (1981) cited one specimen from Sandy Spring and Hench et al. (1987) reported another from Little Bennett Regional Park. Specimens have also been recently collected from Charles County as a result of pitfall trapping at the Indian Head Naval Ordnance Station (Jeff Bossart pers. comm.).

Paradiso (1969) noted that the ranges of the Southeastern Shrew and the Masked Shrew in the eastern United States do not appear to overlap. He described a line running between Washington, DC and Shadyside in Anne Arundel County, Maryland. North of that line, only specimens of *S. cinereus*

have been collected, while all specimens of *S. longirostris* have been found to the south of it. Paradiso went on to suggest that *S. cinereus* will eventually be found to be a resident of the southern portion of the Western Shore section, and that *S. longirostris* may be distributed through more of the Piedmont and northern Western Shore section than is currently documented. Although the *S. longirostris* records from Montgomery County are somewhat farther west, Paradiso's scenario still appears to be essentially correct.

This trapping study was conducted as a cooperative effort between the Patuxent River Naval Air Station (PRNAS), the Maryland Department of Natural Resources (DNR), and St. Mary's College of Maryland. Mr. James McCann (DNR) designed the survey, assisted with placement of the pitfall traps, and identified the *Sorex* specimens captured. Ms. Christina Waldroup, an intern at St. Mary's College, conducted the field work under the direction of her academic advisor, Dr. Ernest Willoughby. Staff biologists and volunteers at PRNAS assisted with field work and provided project supervision.

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Survey for Endangered, Threatened and Rare Vascular Plants in Cove Point Marsh, Calvert County, Maryland

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Introduction

Cove Point Marsh is a 77 hectare nontidal freshwater baymouth barrier wetland (Sipple 1982, 1990), located on the Western Shore of the Chesapeake Bay, just south of Calvert Cliffs, in Calvert County, Maryland. The marsh occupies a shallow depression located just north of Cove Point Lighthouse. Although a salinity measurement from the marsh tested fresh in the early 1990s (R. Mathes, Cove Point Natural Heritage Trust, pers. comm.), brackish water from the Chesapeake Bay was observed to breach the barrier dune during the strong storm surge of Hurricane Fran in September 1996, and a refractometer measured 4 parts per thousand salinity in the marsh two weeks after the hurricane (J. Stevenson, Horn Point Environmental Laboratory, pers. comm.). Species generally associated with salt or brackish marshes such as *Distichlis spicata*, *Setaria magna*, *Kosteletzkya virginica*, *Scirpus robustus*, and *Pluchea odorata* (Gleason and Cronquist 1991), occurred in the marsh just behind the barrier dune. The interior marsh is dominated by *Typha angustifolia* and contains numerous vernal ponds which are fed by Wilbur Creek to the north and Webster Creek to the south.

Vibracores revealed that the soils of Cove Point Marsh are composed of a layer of thick, water logged, organic detritus and peat subtended by approximately two meters of sand, covering thick Miocene blue marl clay (Beardslee and Leatherman 1996). Radiometric dating indicated that a sample drawn from a deep peat deposit in the northern tip of Cove Point Marsh was 1800 years old, ± 70 years (Beardslee and Leatherman 1996).

Site surveys for vascular plants were conducted on 20 and 27 April; 5, 11, 13, 18 and 25 May; 1, 8, 15 and 29 June; 8, 19, 20, 25 and 30 July; 10, 17, 28 and 29 August; 7 and 14 September; and 5 October, 1996. These searches led to the discovery of 14 species of vascular plants regulated by the State of Maryland as threatened or endangered as established in Maryland's Nongame and Endangered Species Conservation Act and the Threatened and Endangered Species Regulations of the Maryland Department of Natural Resources (Code of Maryland Regulations 08.03.08). Additional discoveries included 25 species recognized as highly state rare, state rare, or uncommon in Maryland (Maryland Natural Heritage Program 1994), and the second known collection from Maryland of *Parapholis incurva,* a non-native grass. These are listed below in order of their designated state rarity.

Field season 1996 was wetter and cooler than most historic averages. April - October temperature extremes recorded 17 km west of Cove Point, in St. Marys County, were 1.7^0 C and 35^0 C. April - October rainfall totaled 94.46 cm, which is at least a 16 year high (F. Abell, St. Marys County Weather Station, pers. comm.).

Nomenclature of all taxa in this paper follows Gleason and Cronquist (1991). Herbaria acronyms follow Holmgren et al. (1990). Extant populations are defined by reports entered into the Maryland Forest, Wildlife and Heritage Division's Biological and Conservation Database between 1976 and November 1996, and through the citations given.

Species Lists

Parapholis incurva (L.) C. E. Hubbard (POACEAE).--Calvert County: Cove Point Marsh, 15 June 1996, *Steury 960615.45* (MARY). Determined by Edward Terrell (MARY).

This is the second record for curved sea hard-grass in Maryland. The only other known Maryland collection was from chrome ore piles in Baltimore County in 1954 (Reed 1964). The species is not cited by Brown and Brown (1984) or Norton and Brown (1946), and searches of herbaria at DOV, MARY, NA, PH and US uncovered no Maryland specimens. East coast specimens at US were from Accomac City, Virginia (collected in 1882), Cape Henlopen, Virginia (1916), and on ballast from Camden, New Jersey (1878) (G. Russell, Smithsonian Institution, pers. comm.). This species is also reported from King and Queen and Northhampton Counties, Virginia (Harville et al. 1992); Philadelphia, Pennsylvania (Rhoads and Klein 1993); Carteret and Dare Counties, North Carolina (Radford et al. 1968); and Delaware (Hitchcock 1971).

Curved sea hard-grass is indigenous to the Mediterranean region, extending along the coast of western Europe and in southeastern Wales and England, occurring on gravelly mud banks and open elevated parts of salt-marshes (Hubbard 1968). Introduced in the Americas and Australia (Hubbard 1968), it might be transported to the United States via shipping routes, but has evidentially been unable to establish itself in Maryland. This is supported by the collection, in June, of a single plant at Cove Point in moist sand along the barrier dune.

Zizaniopsis miliacea (Michx.) Doell & Aschers (POACEAE).--Cove Point Marsh, 8 July 1996, *Steury 960708.23* (MARY). Confirmed by Edward Terrell.

Southern wild rice is regulated as endangered by the State of Maryland. Only one other extant population is known in the state in Worcester County. In Cove Point Marsh at least 550 plants collectively occurred at three sites in *Acer rubrum* swamp and *Typha angustifolia* marsh where Wilbur Creek drains into Cove Point Marsh.

Lemna trisulca L. (LEMNACEAE).--Cove Point Marsh, 5 May 1996, *Steury 960505.95* (UNA). Confirmed by L. J. Davenport (Samford University).

Star-duckweed is regulated by the State of Maryland as endangered. Only two other extant populations are reported in the state, one in Allegany County, and in one other site in Calvert County. The species was observed to be abundant in an inundated *Fraxinus profunda* swamp and in a *Clethra alnifolia* shrub swamp along the southern edge of Cove Point Marsh.

Limnobium spongia (Bosc) Steudel (HYDROCHARITACEAE).--Cove Point Marsh, 25 July 1996, *Steury 960725.1* (UNA). Confirmed by Robert Haynes (UNA).

Regulated as endangered by the State of Maryland, two other extant populations of American frog's bit are known from the State, one in Kent County (Steury et al. 1996) and one in Charles County. The species was abundant in the inundated fringe swamps along the southern edge of Cove Point Marsh and was observed in flower in July and August 1996.

Potamogeton foliosus Raf. (POTAMOGETONACEAE).--Cove Point Marsh, 17 August 1996, *Steury 960817.2* (MICH). Tentative identification from vegetative material by Anton Reznicek (MICH) (connate stipules present, basal glands absent).

Leafy pondweed is regulated by the State of Maryland as endangered. Two other extant populations are known from the State in Howard and Harford Counties. In Cove Point Marsh, the species occurred in four colonies under water 0.5 m deep along the Cove Point Liquefied Natural Gas (LNG) boardwalk which transverses Cove Point Marsh to the bay beach. The largest colony measured 2.5 m x 0.5 m in August 1996. The species was not observed in fruit. However, the only vegetatively similar species known to occur in Maryland is the slender pondweed, *Potamogeton pusillus*, which is recognized as "highly state rare" in Maryland.

Scutellaria galericulata L. (LAMIACEAE).--Cove Point Marsh, 8 July 1996, *Steury 960708.7* (COLO). Confirmed by William Weber (COLO).

Marsh-skullcap is recognized as "highly state rare" by the Maryland Heritage and Biodiversity Conservation Program. Three other extant populations are reported in the state from one site in Kent County (Steury et al. 1996), and in Howard and Montgomery Counties. At Cove Point Marsh, one colony occurred along an open edge of *Acer rubrum* swamp at the western entrance to the Cove Point LNG boardwalk. The colony measured 12 m x 1 m, with approximately 300 flowering aerial stems on 8 July 1996.

Carex hyalinolepis Steudel (CYPERACEAE).--Cove Point Marsh, 1 June 1996, *Steury 960601.33* (MICH). Confirmed by Anton Reznicek.

This sedge is regulated as threatened by the State of Maryland. Three other extant populations are known from the state in Dorchester County (2 sites) and in Worcester County. In Cove Point Marsh it was observed in two colonies approximately 1 km apart and scattered along a peninsula extending into the marsh nearly 100 m. The largest colony, which occurred on saturated organic detritus and sand just behind the barrier dune at the base of the peninsula, measured 6 m x 6 m and the smaller patch measured 0.5 m x 0.5 m in June 1996. This population has been extant in Cove Point Marsh since 1946 when specimens were collected there by F. M. Uhler.

Leptochloa fascicularis (Lam.) A. Gray **var. *maritima*** (Bicknell) Gleason (POACEAE).--Cove Point Marsh, 29 August 1996, *Steury 960829.23* (MARY). Confirmed by Edward Terrell.

This annual grass is regulated as endangered by the State of Maryland. Other extant populations in the State are reported from Worcester County (2 sites) and from one other site in Calvert County. In Cove Point Marsh, 27 plants occurred on a tussock flat in a pond near the gut that occasionally drains into the Chesapeake Bay. This population was first found in 1987 by Jim Stasz (pers. comm.) who reported it to be more common in drier years on exposed mud of drought drawdown ponds.

Ammannia latifolia L. (LYTHRACEAE).--Cove Point Marsh, 29 August 1996, *Steury 960829.86* (KE). Confirmed by Shirley Graham (KE).

The Maryland Heritage and Biodiversity Conservation Program recognizes this annual as "state rare." Only three other extant populations are reported from the state, one in Somerset County and two in Worcester County. In Cove Point Marsh 16 plants occurred along 50 m of pond shoreline and in full sun on nearby saturated tussock mats. It was observed in flower and fruit on 29 August 1996.

Fuirena pumila (Torr.) Sprengel (CYPERACEAE).--Cove Point Marsh, 29 August 1996, *Steury 960829.33* (MICH). Confirmed by Anton Reznicek.

This annual umbrella-grass sedge is regulated as endangered in Maryland. Four other extant populations are known in the state, one in Dorchester County, one in Wicomico County and two in Worcester County. In Cove Point Marsh, an estimated 600 plants occurred on tussock mats throughout the interior ponds.

Apocynum sibiricum Jacq. (APOCYNACEAE).--Cove Point, 18 May 1996, *Steury 960518.22* (COLO).

Clasping dogbane is regulated by the State of Maryland as endangered. Three other extant populations are known from the state in Washington County (2 sites) and Montgomery County. In addition, Steury et al. (1996) reported the species from one site in Kent County. At Cove Point, an estimated 250 plants occurred behind the barrier dune just south of Cove Point Marsh, in a dry sandy disturbed site that was a titanium mine in the 1950's.

This specimen was tentatively determined as *Apocynum cannabinum* L. by William Weber who believes *Apocynum sibiricum* might be an ecotype of *Apocynum cannabinum*, following Kartesz and Kartesz (1980). However similar plants, *Steury 080795* (SWT) collected in 1995 in Kent County, were confirmed as *Apocynum*

sibiricum by David Lemke (SWT). *Apocynum sibiricum* differs from *Apocynum cannabinum* in possessing clasping rather than petioled stem leaves, a smaller average length of mature follicles, and frequently, procumbent stems. All of these traits were possessed by the *Apocynum* at this site. Only ten plants were observed to set fruit, probably due to the excessive defoliation of this population by the dogbane beetle (*Chrysochus auratus*). The genus is summarized by Rosatti (1989).

Polygonum densiflorum Meissner (POLYGONACEAE).--Cove Point Marsh, 14 September 1996, *Steury 960914.17* (NA). Confirmed by Kevin Conrad and Fred Meyer (NA).

The State of Maryland regulates *Polygonum densiflorum* as endangered. Other extant populations are known in the state in Anne Arundel, Caroline, Prince Georges, and Queen Anne's Counties (C. Frye, Maryland Heritage and Biodiversity Conservation Program, pers. comm.). In Cove Point Marsh, at least one colony with approximately 50 aerial stems occurred in an inundated *Fraxinus profunda* swamp, in still water 0.6 m deep. It was observed in flower and fruit on 14 September 1996.

Myriophyllum humile (Raf.) Morong (HALORAGACEAE).--Cove Point Marsh, 1 June 1996, *Steury 960601.32* (UNA). Confirmed by Robert Haynes.

The State of Maryland regulates this species of water-milfoil as endangered. Previous reports of extant populations are from Dorchester County (2 sites), Somerset County (2 sites), and three sites in Worcester County. In Cove Point Marsh, six plants occurred on a small saturated tussock flat edging *Typha angustifolia* marsh just west of the peninsular apex in the southeast section of the marsh.

Rhynchospora glomerata (L.) Vahl (CYPERACEAE).--Cove Point Marsh, 20 July 1996, *Steury 960720.38* (MICH). Determined by Anton Reznicek.

This beak-rush is regulated as endangered by the State of Maryland. Eight other extant populations are known from the state, one in St. Marys and one in Wicomico Counties, and six sites in Worcester County. In Cove Point Marsh, approximately 900 plants occurred in a wet mesic *Juncus* meadow at the end of Beach Drive.

Xyris difformis Chapman (XYRIDACEAE).--Cove Point Marsh, 10 August 1996, *Steury 960810.93* (VDB). Determined by Robert Kral (VDB).

The Maryland Heritage and Biodiversity Conservation Program recognizes this yellow-eyed grass as "state rare" in Maryland. Extant populations are known from only two other Maryland counties; Wicomico County (2 sites) and Worcester County (7 sites). In Cove Point Marsh, at least 58 plants were observed during anthesis on 10 August 1996, on *Sphagnum* mats in wet mesic *Juncus* meadow at the end of Beach Drive.

Myosotis macrosperma Engelm. (BORAGINACEAE).--Cove Point, 18 May 1996, *Steury 960518.27* (MO). Annotated as *Myosotis verna* Nutt. var. *macrosperma* (Engelm.) Chapman by Mary Merello (MO), following Yatskievych and Turner (1990).

Big-seed scorpion-grass is an annual which is regulated by the State of Maryland as threatened. Other extant populations in Maryland are known from Charles County (4 sites), Prince Georges County (2 sites), St. Marys County (1 site), and from two other sites in Calvert County. At Cove Point Marsh 28 plants collectively occurred in three sites over 1.4 km on sandy dry/mesic soils. Fifteen plants occurred along the southern edge of the defunct titanium mine, and seven plants occurred in a disturbed site along an edge of *Acer rubrum* swamp approximately 45 m southwest of the Cove Point LNG boardwalk entrance.

Fraxinus profunda (Bush) Bush (OLEACEAE).--Cove Point Marsh, 17 August 1996, *Steury 960817.22* (COLO). Confirmed by William Weber.

Recognized as "state rare to uncommon" in Maryland, pumpkin-ash is known from three other Maryland counties; Dorchester County (1 site), Prince Georges County (1 site) and Wicomico County (6 sites). Along the southeastern edge of Cove Point Marsh, at least 230 pumpkin-ash, most with swollen trunk bases, were found in still water less than 75 cm deep. The largest specimen measured 50.7 cm diameter at breast height. Additionally, at least 10 pumpkin-ash occurred on moist/mesic soils at the end of Poplar Drive.

Eleocharis tortilis (Link) Schultes (CYPERACEAE).--Cove Point Marsh, 10 August 1996, *Steury 960810.3* (MICH). Confirmed by Anton Reznicek.

This spike-rush is recognized by the Maryland Heritage and Biodiversity Conservation Program as "state rare" in Maryland. This is the only known extant population of this species in Calvert County, other extant populations are reported from Baltimore County (1 site), Charles County (1 site), Prince Georges County (1 site), Wicomico County (3 sites), and from five sites in Worcester County. In Cove Point Marsh, four colonies collectively occurred in four sites. The largest colony occurred on sphagnum moss in an open wet mesic *Juncus* meadow and measured 0.8 m x 0.6 m in August. Bordering this site, it occurred in a *Clethra alnifolia* shrub swamp.

Bidens discoidea (T. & G.) Britton (ASTERACEAE).--Cove Point Marsh, 14 September 1996, *Steury 960914.18* (KANU). Confirmed by Craig Freeman (KANU).

This is the only known site for few-bracted beggar-ticks in Calvert County. Recognized as "state rare to uncommon" in Maryland, other extant populations of this annual species are reported in Carroll County (2 sites), Dorchester County (2 sites), Kent County (2 sites), Prince Georges County (1 site), Queen Anne's County (3 sites), Talbot County (1 site), and in Worcester County (3 sites). In Cove Point Marsh, a single plant was found growing on a floating log in a *Fraxinus profunda* swamp fringing the southeastern edge of the marsh. This species might be expected to be more common in drier years.

Carex sparganioides Muhl. **var. *aggregata*** (Mackenzie) Gleason (CYPERACEAE).--Cove Point, 13 May 1996, *Steury 960513.13* (MICH). Identification was annotated by Anton Reznicek as *Carex aggregata* Mack., following Kartesz and Kartesz (1980).

Carex aggregata is regulated as endangered in Maryland. Although historically regarded as rare, this sedge has recently been found in abundance on disturbed sites throughout Maryland, especially northward (C. Frye, pers. comm.). One tuft with four fruiting stems occurred in a grassy meadow near the western entrance of the Cove Point LNG boardwalk.

Carex radiata (Wahlenb.) Small (CYPERACEAE).--Cove Point Marsh, 8 June 1996, *Steury 960608.27* (MICH). Determined by Anton Reznicek.

The State of Maryland regulates *Carex radiata* as endangered, however the species has been underreported and extant populations are now known to occur statewide (C. Frye, pers. comm.). In Cove Point Marsh, four depauperate tufts occurred on hummocks in a *Clethra alnifolia* shrub swamp where Webster Creek drains into Cove Point Marsh.

The following nineteen plant species, historically recognized as "rare to uncommon" in Maryland (Maryland Natural Heritage Program 1994), were also found during the course of this survey.

APIACEAE

Hydrocotyle ranunculoides L. f.--Cove Point Marsh, three colonies in *Acer rubrum* swamp, 30 July 1996, *Steury 960730.1* (UNA). Confirmed by Robert Haynes.

Hydrocotyle verticillata Thunb.--Cove Point Marsh, abundant throughout, 8 July 1996, *Steury 960708.68* (UNA). Confirmed by Robert Haynes.

ASCLEPIADACEAE

Ampelamus albidus (Nutt.) Britton--Cove Point, common on barrier dune, in flower 20 July 1996, *Steury 960720.15* (COLO). Confirmed by William Weber. Listed by the Maryland Natural Heritage Program (1994) as *Cynanchum laeve*, following Kartesz and Kartesz (1980).

Asclepias verticillata L.--Cove Point, eleven plants in sand at abandoned titanium mine, in flower 10 August 1996, *Steury 960810.99* (COLO). Confirmed by William Weber.

COMMELINACEAE

Commelina virginica L.--Cove Point, common in grassy roadside/moist deciduous forest ecotone along Poplar Drive, in flower 10 August 1996, *Steury 960810.98* (COLO). Confirmed by William Weber.

CYPERACEAE

Carex atlantica L. Bailey **var. *capillaceae*** (L. Bailey) Cronq.--Cove Point Marsh, common in shrubland swamp and open wet mesic *Juncus* meadow, 11 May 1996, *Steury 960511.45* (MICH). Confirmed by Anton Reznicek.

Carex canescens L.--Cove Point Marsh, abundant in shrubland swamp and *Osmunda regalis* marsh, 5 May 1996, *Steury 960505.44* (MICH). Confirmed by Anton Reznicek.

Carex complanata Torr. & Hook--Cove Point, one tuft in stand of mesic deciduous forest, and more common in wet mesic *Juncus* meadow, 20 July 1996, *Steury 960720.46* (MICH). Confirmed by Anton Reznicek.

Carex seorsa Howe--Cove Point Marsh, common in shrubland swamp, 5 May 1996, *Steury 960505.45* (MICH). Confirmed by Anton Reznicek.

Cyperus erythrorhizos Muhl.--Cove Point Marsh, one plant on muskrat lodge in *Typha angustifolia* marsh, 20 July 1996, *Steury 960720.92* (MICH). Confirmed by Anton Reznicek.

Eleocharis flavescens (Poiret) Urban **var. *olivacea*** (Torr.) Gleason--Cove Point Marsh, dominant species on tussock flats in interior ponds, 29 August 1996, *Steury 960829.28* (MICH). Confirmed by Anton Reznicek. Listed as *Eleocharis olivacea* by the Maryland Natural Heritage Program (1994), following Kartesz and Kartesz (1980).

Rhynchospora gracilenta A. Gray--Cove Point Marsh, one 0.9 m x 1.4 m colony in wet mesic *Juncus* meadow at end of Beach Drive, 20 July 1996, *Steury 960720.43* (MICH). Confirmed by Anton Reznicek.

JUNCACEAE

Juncus coriaceus Mackenzie--Cove Point Marsh, abundant in wet mesic *Juncus* meadow at end of Beach Drive, 8 July 1996, *Steury 960708.93* (KANU). Confirmed by Ralph Brooks (Black & Veatch).

LEMNACEAE

Lemna perpusilla Torr.--Cove Point Marsh, abundant in *Fraxinus profunda* swamp, 29 August 1996,

Steury 960829.87 (UNA). Confirmed by L. J. Davenport.

LENTIBULARIACEAE

Utricularia gibba L.--Cove Point Marsh, abundant in ponds and inundated swamps, in flower 20 July 1996, *Steury 960720.57* (COLO). Confirmed by William Weber.

PASSIFLORACEAE

Passiflora lutea L.--Cove Point, grassy roadside/forest stand ecotone at end of Poplar Drive, in flower 19 July 1996, *Steury 960719.99* (COLO). Confirmed by William Weber.

POACEAE

Glyceria septentrionalis A. Hitchc.--Cove Point Marsh, one tuft in shrubland swamp, 8 June 1996, *Steury 960608.23* (MARY). Confirmed by Edward Terrell.

SMILACACEAE

Smilax bona-nox L.--Cove Point, abundant in sand at abandoned titanium mine, 18 May 1996, *Steury 960518.93* (BAYLU). Confirmed by Walter Holmes (BAYLU).

Smilax walteri Pursh--Cove Point Marsh, abundant in wet mesic shrubland swamp, 11 May 1996, *Steury 960511.52* (BAYLU). Confirmed by Walter Holmes.

Acknowledgments

Special appreciation is extended to the Cove Point Natural Heritage Trust, to Judy Unger of the Flora of North America Project in St. Louis, Missouri, to Lynn Davidson, Maryland Natural Heritage Program, to Paul Peterson, Smithsonian Institution, and to A. Tucker (DOV), J. Reveal (MARY), K. Conrad (NA), K. Williams (PH), and G. Russell (US) for checking their collections. Appreciation is also extended to the authorities cited in this paper who confirmed specimen identifications, and to the anonymous reviewers for their comments on the manuscript.

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NATURAL HISTORY SOCIETY OF MARYLAND, INC.
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